DOCUMENT RESUME

ED 411 224 SP 037 514

AUTHOR Luft, Julie A.; Buss, Ray; Ebert-May, Diane; Eslamieh, Chula
TITLE A Report of Initial Certification in Science and Mathematics at Arizona Regents' Universities.
PUB DATE 1997-03-00
NOTE 67p.; Study supported by the Eisenhower Mathematics and Science Program, Arizona Board of Regents.
PUB TYPE Reports - Research (143)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Elementary Secondary Education; Higher Education; *Mathematics Education; *Mathematics Teachers; Preservice Teacher Education; Program Evaluation; *Science Education; *Science Teachers; *Teacher Certification; Teacher Education Curriculum; Teacher Education Programs
IDENTIFIERS *Arizona; Dwight D Eisenhower Math and Science Educ Program

ABSTRACT

This report discusses a project to assess the programs for initial certification of science and mathematics teachers at Arizona Regents' universities. The assessment addressed the participants, recommended coursework for certification, the curriculum for each program, and the faculty and staff involved in each initial certification program. Information about initial certification programs was collected from all Regents' Universities (Arizona State, Arizona State University West, Northern Arizona University, and the University of Arizona) and compared to both the national and state recommendations for these programs. Data were collected by a survey of a sample of faculty (n=66) and by examination of documents. Examination of initial certification programs in science and mathematics showed that preservice teachers did not receive adequate training. In particular, secondary students pursuing a minor in education were not required to take courses in mathematics or science pedagogy. Elementary education majors did not have adequate subject matter preparation in either science or mathematics. Most education faculty were tenure-track and had less than six years of service. There were more scientists than science educators, leading to concern about a lack of exemplary model teaching. Reform of curriculum, instruction, and assessment were found to be the greatest challenge with deficits found in all three areas. Appendix A comprises the list of information deemed important for the study and Appendix B presents the faculty and staff survey. (Contains 25 references.) (JLS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 411 224

A Report of Initial Certification in Science and Mathematics at Arizona Regents' Universities

Eisenhower Mathematics and Science Program

Arizona Board of Regents

March 1997

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY

J. Luft

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Julie A. Luft, University of Arizona

Ray Buss, Arizona State University West
Diane Ebert-May, Northern Arizona University
Chula Eslamieh, Arizona State University

SP037514

BEST COPY AVAILABLE

Acknowledgments

This project was the result of variety of people who gave their time and thoughts about mathematics and science initial certification programs in Arizona.

At Arizona State University, the assistance of Lynn Abrassart was critical in collecting and organizing the data. Without her help, the information about Arizona State University initial certification programs would not have been completed in a timely manner. At Arizona State University West, Sandy Griffith assisted in collecting the data on initial certification. At the University of Arizona, the following faculty and staff members made significant contributions to this project: Peggy Douglas, Assistant Dean in the College of Education; Bill Ames, Chair of the Initial Teacher Preparation Committee in Teaching and Teacher Education; Cathy Miller, Mathematics Education, Teaching and Teacher Education; and Pat Murray, Student Services, the College of Education. The graduate assistant on this project, Jim Withers, was also critical in the compiling and analyzing of the data. Tom Harrison, from Northern Arizona University, also provided assistance in the development of this report.

Finally, we wish to thank the Eisenhower Mathematics and Science Program of the Arizona Board of Regents for supporting this study. Paul Tweeten, Senior Program Coordinator, was essential in conceptualizing and supporting this project.

Table of Contents

Introduction 1

Section I: Questions for Study 2

Section II: Methods 3

An Overview 3

Data Collection 3

Survey 3

Sample Population/Participant Selection 4

Data Analyses - Documents 5

Data Analyses - Survey 6

Section III: Findings and Discussion 7

Mission Statements and Initial Certification 7

1.0 University Mission Statements 7

1.1 Colleges and Centers of Education Mission Statements - 9

1.2 College of Arts & Sciences Mission Statements - 10

1.3 K-12 School District Mission Statements 11

1.4 Concluding Remarks: Mission Statements 13

Initial Certification Programs 14

2.0 Admissions to Initial Certification Programs 14

2.1 Traditional Initial Certification Programs in Science 16

2.2 Traditional Initial Certification Programs in Mathematics 18

2.3 Alternative Initial Certification Programs in Mathematics or Science 19

2.4 Community-based University Partnership Programs 20

2.5 Experiences that Earn Certification Credit 20

2.6 Advising of Initial Certification Students 21

2.7 Supervision of Student Teachers 21

2.8 Programs/Projects that Support the Initial Certification of Teachers 23

2.9 Concluding Remarks: Initial Certification Programs 24

Students in Initial Certification Programs 25
3.1 Awarded Certificates & Gender of Initial Certification Students 25
3.2 Ethnicity of Initial Certification Students 26
3.3 Enrollment and Certification 27
3.4 Concluding Remarks: Initial Certification Students 29
Faculty and Staff who are Involved in Initial Certification Programs 30
4.0 Profiles of Mathematics and Science Educators 30
4.1 Professional Activity of Mathematics and Science Educators 32
4.2 Concluding Remarks: Faculty and Staff 33
Curriculum, Instruction, and Assessment of Faculty and Staff 35
5.0 Curriculum Materials of Mathematics and Science Educators 35
5.1 Instruction of Mathematics and Science Educators 37
5.2 Assessment Utilized by Mathematics and Science Educators 39
5.3 Concluding Remarks: Curriculum, Instruction, and Assessment 40
Section IV: Recommendations 42
Bibliography 44
Appendix A 46
Appendix B 49
Appendix C 55

A REPORT OF INITIAL CERTIFICATION IN SCIENCE AND MATHEMATICS AT ARIZONA REGENTS' UNIVERSITIES

Introduction

This project assesses the programs for initial certification of science and mathematics teachers at Arizona Regents' Universities. In this report, the term "initial certification program" will refer to the course of study that both degree-holding and degree-seeking students engage in as they acquire their first teaching certificate. This assessment addresses the participants, the recommended courses for certification, the curriculum for each program, and the faculty and staff involved in each initial certification program. In order to assess the status of initial certification programs in Arizona, information about initial certification programs in mathematics and science was collected from all Regents' Universities and compared to both the national and state recommendations for these programs. This report on this project is divided into four Sections: questions, methods, findings and discussion, and recommendations.

Section I, Questions for Study, introduces the basic issues guiding this assessment.

Section II, Methods, provides a concise overview of the methods used to answer the guiding questions, including criteria for participant selection, modes of data collection, and analytical procedures.

Section III, Findings and Discussion, combines findings and discussion with graphical representations and numerical analyses that are supplemented with explanations and interpretations.

Section IV, Recommendations, summarizes the major findings while offering suggestions for the on-going development of Arizona's initial certification programs.

The report adds to the growing body of knowledge about mathematics and science education in the state of Arizona that has been generated over the last two to three years. Specifically, this report complements the *K-12 Mathematics and Science Education in Arizona: A Status Report* (Sowell, et al., 1995), *Arizona Educational Profiles: 1990-1991* (Arizona Department of Education, 1993), and the *Final Report of the NAU Symposium on Systemic Reform in Science and Mathematics Education* (Harrison, 1997).

Section I: Questions for Study

This project describes the status of initial certification in mathematics and science programs at Arizona Regents' Universities. In order to provide a comprehensive examination of initial certification in mathematics and science programs in Arizona, the following questions were asked:

- How do the universities, colleges, centers, and K-12 school districts involved in initial certification programs address initial certification of mathematics and science students in their mission statements?

- How are initial certification programs in mathematics and science at each Arizona Regents' University configured?

- Who are the students in initial certification programs in mathematics and science at Arizona Regents' Universities?

- Who are the faculty and staff involved in initial certification programs in mathematics and science at Arizona Regents' Universities?

- What are the modes of curriculum, instruction, and assessment of faculty and staff who are involved in initial certification programs in mathematics and science?

Surveys, documents, catalogues, and interviews were used to answer the above questions. Each major question was examined through a series of sub-questions. Information about each guiding question was acquired from each of the Arizona Regents' Universities: Arizona State University, Arizona State University West, Northern Arizona University, and the University of Arizona.

It should be noted that the analysis in this report was based upon the available and provided data. In some cases, the absence of data or the limited amount of data prevented a thorough analysis within an area. These areas are noted within the report.

Section II: Methods

The nature of initial certification programs for mathematics and science educators influenced the research methods that were employed. Information that was related to mission statements, program participants, and certification programs was obtained from primary documents and university records. Data pertaining to the mathematics and science educators who are involved in initial certification were collected through a survey. Documents were analyzed quantitatively and qualitatively, while survey data were quantitatively assessed.

An Overview

During the spring of 1996, a team of science and mathematics educators from each of the four Arizona Regents' Universities generated a list of questions pertaining to initial certification programs in science and mathematics. This list (Appendix A) was revised and served as a guide to data collection. The team decided that the required information would be collected through two venues: university records and documents, and a survey of mathematics and science educators. The team also decided that data should cover the last three years at all institutions. The process of collecting university records and documents is briefly described below, and the development and administration of the survey is located in the following section.

Data Collection

Each team member was responsible for collecting the records and documents listed on the data collection guide from his/her respective institution: Arizona State University, Arizona State University West, Northern Arizona University, and the University of Arizona. In several instances, team members contacted Assistant Deans, Directors of Teacher Preparation Programs, or colleagues in order to collect the required information. Data collection, at times, was problematic and time consuming as current records were not always readily available. Within five months, each team member had acquired the requested records and documents that portrayed the status of science and mathematics initial certification programs at his/her university.

Survey

In addition to the collection of university records and documents, this study also surveyed the faculty and staff involved in science and mathematics initial certification programs. The survey was used to profile those who are involved in the education of initial certification students in mathematics and science education. At the onset, it was decided that the survey should represent the recommendations for the professional development of science and mathematics teachers, and it should reveal how mathematics and science educators plan their curriculum, instruct their students, and utilize assessments.

To initiate the process of survey development, three steps were taken. First, guidelines and recommendations for teacher preparation were examined from the *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991). These guidelines became the framework of the survey. Second, areas within the survey framework were further elaborated and operationalized through an examination of similar studies that had been completed in other states (see Baird, Prather, Finson, & Oliver, 1994; Finson, Fitch, Lisowski, & Foster, 1996). Third, examples that could be used in the survey areas of curriculum, instruction, and assessment were collected through interviews with mathematics and science educators and from the literature on mathematics and science education. Each source of information contributed to the development of the final survey. Throughout the summer and fall of 1996, the survey was continually revised by team members for reader ease and accurate representation of mathematics and science education.

The final survey (Appendix B) contained five sections: demographic information, levels of professional activity, use of curriculum, modes of instruction, and utilization of assessment. When the final survey was constructed, a field pre-test was conducted among educators who would not be receiving the survey (Fowler, 1993). Vague questions, awkward phrasings, and confusing data collection schemes were identified and modified. A second field test revealed that the survey was ready to be disseminated.

The survey was mailed to identified participants at Arizona Regents' Universities. Follow-up messages were sent to encourage participants to complete their surveys. The response rate varied among universities. The highest response rate was 72%, while the lowest response rate was 25%. The variation in responses resulted in an overall response rate of 65%. The homogenous nature of the identified sample population suggests that the non-respondents were not a distinct group within the sample population. Thus, we feel confident in assuming that the surveys completed do represent the entire population of mathematics and science educators at Arizona Regents' Universities (Fowler, 1993).

Sample Population/Participant Selection

Defining the sample population is an important part of articulating "the sample frame" (Fowler, 1993). This study followed the suggestions of Best (1977) and Fowler (1993) for identifying a sample population. From the larger population of people who are involved in mathematics and science education at Arizona Regents' Universities, we selected a group that reflected the intent of this study and who could be sampled comprehensively. Our identified population is a limited population and exists within departments and colleges within each Arizona Regents' University.

Participants in this study consisted of university faculty or staff that contribute to initial certification programs for science and mathematics teachers. A participant, for example, could be a professor, a lecturer, a graduate student, or adjunct faculty member. While the

duration of the appointment and appointment that the participant held was not narrowed, the capacity in which the participant worked with initial certification students was carefully defined. Participants were selected to receive our survey if they complied with any of the following: 1) they taught courses in science or mathematics that were specifically developed for initial certification students, 2) they taught courses in science or mathematical pedagogy that were taken by initial certification students, or 3) they worked extensively with initial certification students in science or mathematics. The above mentioned parameters resulted in the identification of one-hundred-three participants.

The following examples further clarify the identification process. A biology professor who teaches Introductory Biology and an advanced science course was not considered to be an eligible participant. While we acknowledge that initial certification students are participants in Introductory Biology and advanced classes, these courses are not typically developed with initial certification students in mind. Likewise, teacher educators who conduct general courses on pedagogy and philosophy to all students (elementary through secondary) were not considered eligible to participate in our study. Instead, a participant would be a mathematics professor who teaches advanced courses to mathematics majors and supervises student teachers in both elementary and secondary mathematics. Teacher educators who specifically offer courses that pertain to initial certification students in mathematics education or science education were also considered to be eligible participants. It seems important to state at this time that we, as others (see Lazarowitz & Tamir, 1994; Songer & Mintzes, 1994; Sundberg & Armstrong, 1993; Tobias, 1992), are concerned about science and mathematics for all university students and consider it an area worthy of study, yet it is not the focus of this paper.

Data Analyses - Documents

The university records and documents we collected required a variety of analysis methods. The data that represented numerical trends were analyzed using statistical methodologies, while other data (primary documents) were examined qualitatively. In either instance, analysis methods that allowed for the best understanding and interpretation of the data were applied case by case.

Mean, median, and mode were the frequently used in examining numerical data. Often these frequencies were posted over the period of time that the data were collected (three years). When possible and appropriate, numerical comparisons between universities were made. Depending upon the numerical values within these comparisons, either descriptive or comparative analyses were made. Graphical representations were created to represent the salient findings.

Two approaches were used in examining primary documents: grounded theory and comparison. Grounded theory (Bogdan & Biklen, 1992; Glasser & Strauss, 1967) was used when documents needed to be analyzed qualitatively. This process allows researchers to specifically examine and identify the major themes or trends that are evident within various documents. Findings from documents that were analyzed using this

methodology are reported in themes and trends. Comparison was used to understand how the collected documents aligned with the *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991).

Data Analyses - Survey

The survey was comprised of closed questions that encompassed five general areas: background information, professional activity, curriculum, instruction, and assessment. The survey questions either made a statement that required a specific response (e.g. college or department in which you are appointed) or required a response that was selected from a Likert scale (e.g. How often do you utilize rubrics in your classroom?). Likert scale questions also required that the respondent indicate whether the response related primarily to their content or pedagogical courses. For example, a respondent might indicate that she uses rubrics frequently in her class. She would also have to indicate that she used rubrics in her content courses, pedagogical courses, or both.

Both discrete and continuous data from the survey were entered into the computer. Either t-tests or two-way ANOVA procedures were used to analyze the data. When significance was found, and if appropriate, follow-up pair-wise comparisons were made. SPSS was the statistical package that was used to analyze and graph the data.

Section III: Findings and Discussion

The findings will be discussed in the order that the questions from the study were presented. Both quantitative and qualitative findings about mathematics and science programs and their participants will be presented. After the major findings are discussed, a summary statement will address considerations that should be attended to by those who guide, instruct, and participate in initial certification programs for mathematics and science students.

How do the universities, colleges, centers, and K-12 school districts involved in initial certification programs address initial certification of mathematics and science students in their mission statements?

Mission statements are typically brief and concise statements that are crafted by people within an organization to state the purpose of the organization. At Arizona Regents' Universities, each university, college, and center has a mission statement describing their purpose. Likewise, K-12 school districts also have their own mission statements.

Ideally, university, college, and center mission statements should be consistent with the programs and courses that are offered, and they should represent the intent of faculty and staff. The same is true for the mission statements that are crafted by K-12 school districts. The mission statements of universities, colleges, centers, and districts play an important role in initial certification programs for mathematics and science educators. They provide a framework that describes the emphasis that will be present within initial certification programs and they describe the settings in which future teachers will work. For initial certification students in mathematics and science, the mission statements influencing their programs of study should be consistent with the *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991).

1.0 University Mission Statements

Missions statements from each of the four Arizona Regents' Universities were collected from catalogues and administrative offices. The process of collecting mission statements revealed that they are not always apparent or accessible to each person in the university. The collected mission statements are located on the following page.

University Mission Statements	
Arizona State University	The university's mission is to provide outstanding programs in instruction, research, and creative activity, to promote and support economic development, and to provide service appropriate for the nation, the state of Arizona, and the state's major metropolitan area. To fulfill its mission, ASU places special emphasis on the core disciplines and offers a full range of degree programs-baccalaureate through doctorate. To become competitive with the very best public universities, the institution recognizes that it must offer quality programs at all degree levels in a board range of fundamental fields of inquiry. ASU will continue to dedicate itself to superior instruction, to excellent student performance, to original research, creative endeavor, and scholarly achievement and economic development activities. ASU Catalog
Arizona State University West	ASU West offers quality academic programs in the arts and sciences as well as in selected professional fields. The campus is committed to encouraging the educational, economic, cultural, and social development of the metropolitan area. ASU West prepares students to be successful in the global society of the 21st century by engendering a responsiveness to change and an appreciation of intellectual, cultural, gender, and generational diversity. ASUW Catalog
Northern Arizona University	To serve the citizens of Arizona as the state's premier residential university, by preparing students to be well-educated, informed, and productive participants in their communities and the larger society. To offer graduate programs and support research areas that are important to the development of the state and the region. To provide an educational environment which values diversity of the human experience and a global perspective on issues. To encourage independent and critical thought and a creativity its students and employees as well as the habits of cooperation and teamwork. To address critical challenges facing the American Southwest by providing educational opportunities in both residential and non-residential environments. To offer instruction through educational partnerships throughout the state that employ a variety of strategies to support distance learning and provide opportunities for faculty and staff development. To provide public service in areas such as teacher education, natural resource management, and rural community development.
University of Arizona	To prepare students for an increasingly diverse and technological world and to improve the quality of life for people in Arizona and the nation. To provide distinguished undergraduate, graduate, and professional education; excel in basic and applied research and creative achievement; and integrate these activities and achievements of regional, national, and international significance into everyday life.

The mission statements supplied by each of the Arizona Regents' Universities were consistent with one another. As consistent documents, all mission statements have the common theme of meeting the needs of the state and the corresponding regions. In addition, they advocate participation at the local, national, and international level; a commitment to instruction; and the importance of research. Interestingly enough, the only mission statement that addressed the preparation of teachers was from Northern Arizona University.

BEST COPY AVAILABLE

1.1 College of Education & Center for Excellence in Education Mission Statements

Each College of Education and the Center for Excellence in Education provided an adopted mission statement. The collected mission statements are:

Colleges of Education & Center for Excellence in Education Mission Statements	
Arizona State University	As dynamic, proactive entity carrying out knowledge creation and human capital formation for the benefit of Arizona and the nation, the College of Education provides and supports an infrastructure for three primary reasons: 1) preparing teachers, other professional educators, and researchers to meet the educational needs of children, youth, and adults at high levels of mastery; 2) preparing education practitioners, researchers, and policy makers to contribute to the creation of knowledge and the making of wise policy decisions regarding societal needs; and 3) serving as a state community of educational learners to provide a continuing support/outreach system for practitioners and communities in the effective delivery of education services to all students. Memorandum 8/9/96
Arizona State University West	The College of Education faculty is dedicated to the promotion of the full development of human beings. Through innovative, traditional and interdisciplinary programs and services, the faculty participates in partnerships to improve the quality of life of those we serve. Opportunities are provided for personal and professional growth. We promote a lifelong passion for learning and involvement. ASUW Catalog - adopted 1994
Northern Arizona University	The mission of The Center for Excellence in Education of Northern Arizona University is to prepare education professionals to create schools of tomorrow. This mission is based upon the fundamental beliefs in the dignity and inherent worth of all people and in the central role of education in a democratic society. It is further based upon beliefs that the preparation of educational professionals is an interdisciplinary, university-wide responsibility (as well as a responsibility of the profession itself) and that learning to be an education professional is developmental, spanning the educator's entire professional career. Finally, it is based upon the belief that a strong content background and professional competence are essential for the future educator. adopted 3/22/93
University of Arizona	The mission of the College of Education is to fulfill a unique and critical role in the creation and preservation of knowledge. We prepare professionals in the following areas: teaching and learning, multicultural and bilingual education, testing and performance assessment, systems and organizations, policy and finance, language and literacy, individuals with exceptionalities, and rehabilitation counseling and case practices. This is accomplished in a context in which rigorous standards of scholarship are applied, the highest of ethical, legal, and professional standards are upheld, students and faculty collaborate to conduct and disseminate research for Arizona and elsewhere, and the leaders of American education and human services emerge and are supported. revised 5/13/96

The mission statements supplied by the Colleges of Education and the Center for Excellence in Education do not specifically address the preparation of mathematics or science teachers, but their mission statements do offer a commitment to the preparation of

BEST COPY AVAILABLE

initial certification teachers. Each statement does discuss the importance of preparing knowledgeable educators that can meet the needs of their community. This is congruent with the recommendations made by both the *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991). For university mathematics and science educators this translates into preparing initial certification students with the pedagogy that is espoused in the *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991). Furthermore, meeting the needs of the community, at either the state or the national level, should result in partnerships created and utilized by initial certification programs (National Council of Teachers of Mathematics, 1991; National Research Council, 1996).

The *National Science Education Standards* (1996) and the *Professional Standards for the Teaching of Mathematics* (1991) suggest an interdisciplinary approach to science and mathematics education, and the need for teacher education programs to be informed entities that are based upon the knowledge of mathematics and science education. Mission statements from both Arizona State University West and Northern Arizona University state the importance of interdisciplinary programs, while the mission statements from Arizona State University and the University of Arizona reinforce the creation of knowledge. An emphasis in one area does not result in the exclusion of the other. Instead, both areas are present with one area receiving an emphasis.

1.2 College of Arts & Sciences Mission Statements

When available, Colleges of Arts and Sciences provided their draft or adopted mission statement. The following mission statements were collected:

College of Arts & Sciences Mission Statements	
Arizona State University	The College of Liberal Arts and Sciences mission statement identifies student learning as a core value. The goal is for students to "understand and critically evaluate themselves, their society, their culture; to understand the natural and social world and evaluate the information they receive about that world; to appreciate scholarly and artistic accomplishments...; and to value scholarship and lifelong, active learning." Memorandum 9/22/96
Arizona State University West	The College of Arts and Sciences offers academic programs that prepare students to take their place as active participants in a rapidly changing social, political, and natural environment. The program seeks to provide students with the following: 1) the skills necessary for independent thinking and effective expression; 2) an understanding and appreciation of diverse culture both past and present; 3) a sensitivity to the aesthetic dimensions of human endeavor and the natural environment; and 4) an appreciation and understanding of scientific perspectives and methods as tools for understanding nature and society. ASUW Catalog

BEST COPY AVAILABLE

College of Arts & Sciences Mission Statements (con't)	
Northern Arizona University	The College of Arts and Sciences: offers students a strong liberal arts education through integrated study in all the basic arts and sciences; provides an academic foundation in fundamental disciplines; prepares students throughout the university for success in their professional, community, and personal lives. Graduate and Undergraduate education - The College of Arts and Sciences is focused on the objective of developing a premier undergraduate program at Northern Arizona University. Excellence in teaching and research are the pillars supporting this effort.... Teaching - By providing the foundation of a liberal arts education, we are creating an education for life long learning beyond the needs of a specialized career. The college recognizes the need to help students master the basics; communication skills, both written and spoken; modern languages; critical reasoning; and mathematical models of real-life problems.... Research - In addition to extending the frontiers of knowledge throughout research, this college encourages students to participate in the organized pursuit of knowledge as both graduate and undergraduate students. Research in an integral component of a high quality undergraduate education and an essential component of a graduate education.... Service -The college is committed to providing quality service to the university and community in such typical areas as: community colleges and K-12 education; communities throughout rural Arizona; Native American education policy, research and tribal issues; and the Colorado Plateau. Abbreviated. Working Draft 11/96
University of Arizona	No official statement.

Similar to the mission statements by the Colleges of Education and the Center for Excellence in Education, the mission statements by the College of Liberal Arts and Sciences, and the Colleges of Arts and Sciences make no specific recommendations for the preparation of mathematics or science educators. Instead, they posit that their programs prepare students to be critical and independent thinkers and participants within a continually changing society. In addition, permeating each mission statement is the desire to create life-long learners. The *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991) specifically state that science and mathematics teachers should have opportunities for intellectual growth, and that science teachers should know that professional development is a continuous, life long process.

1.3 K-12 School District Mission Statements

Mission statements were collected from fifteen school districts who frequently collaborate with Arizona Regents' Universities. While some mission statements were similar, no two were exactly the same. The diversity among mission statements reinforces the unique composition of administrators, teachers, parents, and students that comprise each district. Just as no two mission statements were exactly the same, no two districts are identical.

BEST COPY AVAILABLE

Selected K-12 School District Mission Statements	
Roosevelt School District	The mission of the Roosevelt School District, as the embodiment of the community's commitment to the success of all its children, is to guarantee that all students experience unique personal and academic triumph of leaders through full utilization of community resources, current technology, international interaction, partnerships with parents, and continuous performance-based education.
Sunnyside School District	The mission of Sunnyside Unified School District is to assure that all students served by the District learn the skills, knowledge, behaviors, and attitudes necessary for productive living in a changing, democratic, multicultural society.
Phoenix Elementary School District	The mission of the Phoenix Elementary School District No. 1 is to provide, for all students, quality education characterized by high expectations and measurable academic achievement in a safe, clean, caring environment.

Although diverse, the mission statements supplied by several Arizona school districts did reveal a common theme of "quality education for all students." The emphasis on quality education for "all" students is in agreement with the *National Science Education Standards* (National Research Council, 1996), *Science For All Americans* (1990), and the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991). The *Professional Standards for Teaching Mathematics* specifically states:

> As a professional organization and as individuals within that organization, the Board of Directors sees the comprehensive mathematics education of every child as its most compelling goal.
>
> By "every child" we mean specifically-
>
> - students who have been denied access in any way to educational opportunities as well as those who have not;
> - students who are African American, Hispanic, American Indian, and other minorities as well as those who are considered to be a part of the majority;
> - students who are female as well as those who are male; and
> - students who have not been successful in school and in mathematics as well as those who have been successful. (p. 4)

Specific recommendations for the teaching or learning of mathematics and science and the need for professional development among K-12 educators were not found in the collected K-12 school district mission statements. Although occasionally school district mission statements discussed the need to include technology in the school setting.

District mission statements reinforce the basic premise that all students can learn science or mathematics, and that all students should have equitable opportunities to do so. Creating this environment requires that initial certification programs in mathematics and

BEST COPY AVAILABLE

science education espouse the importance of high expectations, and that they disseminate instructional practices that are congruent with effective instruction for all students.

1.4 Concluding Remarks: Mission Statements

University, college, and center mission statements guide the programs and instructors that are responsible for educating science and mathematics teachers who are seeking initial certification. Likewise, district mission statements provide valuable guidelines for the ideology that should be espoused in initial certification programs for mathematics and science educators. Together, these mission statements should be consistent the standards for the professional development of mathematics and science educators.

In Arizona, the mission statements from universities, colleges, centers, and schools districts addressed some of the qualities that should be evident in an initial certification program in mathematics and science education. While not specifically crafted to speak about the initial certification of mathematics and science educators, the mission statements did reinforce tenets of learning that should be emphasized for initial certification students (e.g. all students can learn, the importance of knowledge, and interdisciplinary nature of science).

In the future, mission statements should be shared among all participants within the originating organization and with all individuals or groups who are involved with the organization. Specifically, university, college, center, and school district mission statements should be shared with their faculty and staff, and with one another. Through this sharing, individuals and organizations will gain an understanding about one another, and how the shared mission statements support common goals. Ultimately, this sharing will result in meaningful discussions about mission statements and plans of action to support them.

How are the initial certification programs in mathematics and science at each Arizona Regents' University configured?

Initial certification programs are designed specifically for either undergraduates, graduates, or post-baccalaureates so that they may teach in the elementary or secondary classroom. They contain coursework in mathematics or science, content courses that are specifically designed for future teachers, methods courses, general education courses, and field experiences. This report specifically highlights those programs that lead to certification in mathematics or science. There are three types of initial certification programs that are offered at Arizona Regents' Universities. They are:

- Bachelor's programs - These programs lead to a first degree and a certificate to teach in either mathematics, science, or a specialization in mathematics or science.
- Post-degree programs - These programs are for students who have already earned a degree in mathematics or science, and who are seeking certification so that they may teach in the K- 8 or 9 -12 setting.
- Master's of Art in Teaching programs (MAT) - These programs lead to a Masters and they may include a certificate to teach mathematics or science. Students may or may not already have a first degree.

Arizona Board of Regents' Universities offer the following initial certification programs for students:

Institution	Initial Certification Programs/Degrees		
	Bachelor of Art/Science in Education	Post-degree certification	Master of Art in Teaching*
Arizona State University	X	X	X
Arizona State University West	X	X	
Northern Arizona University	X	X	X
University of Arizona	X	X	

*may or may not include a certificate to teach

2.0 Admissions to Initial Certification Programs

Each Arizona Regents' University has developed specific admission criteria for undergraduates and post-baccalaureates. Admission criteria typically includes the GPA of the student, the number of credit hours completed, and the completion of required courses. Most students are officially enrolled in an education program after they have

BEST COPY AVAILABLE

completed 56 hours of coursework (provided they satisfy the admission criteria). The admission criteria for each Arizona Regents' University is as follows:

Institutions	Admission Criteria for Undergraduate Degree
Arizona State University	Students who are admitted to ASU during their freshman and sophomore years may also be admitted to the College of Education with professional status. Students are considered eligible for admission to the professional program if they meet the following criteria: 1) admission to ASU as a classified student; 2) a minimum GPA of 2.50; 3) completion of 56 hours by the time that are admitted to the program; 4) submission of ACT or Pre-Professional Skills Test scores; 5) completion of specified English classes and general studies courses with a C or better; and 6) a special application with supporting material (evidence of experience in the field).
Arizona State University West	In order to be admitted as an undergraduate education major, students must: 1) be admitted to ASUW as degree-seeking student; 2) complete a minimum of 56 semester hours of post secondary coursework; 3) attain a GPA of 2.50 or higher; 4) have demonstrated proficiency in writing, mathematics, science, computer literacy, and their areas of expertise (grade of C or better).
Northern Arizona University	Not available.
University of Arizona	In order to be apply for an undergraduate degree, the student must: 1) have completed no fewer that 56 semester credit hours, 2) hold a cumulative GPA of 2.50 on the most current 56 units, and 3) the Upper Division Writing Proficiency Examination must be completed prior to admission. Students will be evaluated on: 1) academic achievement; 2) language proficiency in English and other languages in the southwest; 3) multicultural experiences that relay an understanding and ability to work with members of different racial and ethnic backgrounds, and 4) relevant or volunteer experience in education.

Below are the Admission Criteria the post-baccalaureate degree:

Institutions	Admission Criteria for Post-certification Elementary and Secondary
Arizona State University	In order to be considered eligible for entry to the College of Education, post-baccalaureate programs, a student must have: 1) a bachelor's degree from an accredited institution, 2) a cumulative GPA of 2.50 or better for the last 60 hours of credit earned; and 3) submission of a completed application form and supporting materials by the stated deadline.
Arizona State University West	In order to be considered for admission to the post-baccalaureate programs, in education, students must: 1) submit transcripts indicating an earned bachelor's degree from an accredited institution; 2) have a cumulative GPA of 2.50 or higher on the last 60 hours of coursework; 3) be admitted to ASUW as a non-degree student; and 4) submit a completed application form for the Post-baccalaureate Programs for Teacher Certification by the deadline dates.

BEST COPY AVAILABLE

Institutions	Admission Criteria for Post-certification (con't) Elementary and Secondary
Northern Arizona University	The requirements for admission into the post-degree elementary program are admission into the graduate college and admission into the Teacher Education program. In addition, the student must have completed specified coursework in science, math, history, fine arts, and political science. In order to be admitted to the post-secondary certification program, students must be admitted into the Graduate College and into the Teacher Education program, as well as having written approval of their teaching major by a faculty member in their subject area.
University of Arizona	In order to apply to the College of Education, post-baccalaureate programs, a student must have: 1) a bachelor's degree from an accredited institution; 2) a cumulative GPA of 2.50 or better for the last 60 hours of credit earned; and 3) submission of a completed application form and supporting materials by the stated deadline. Students will be evaluated on: 1) academic achievement; 2) language proficiency in English and other languages in the southwest; 3) multicultural experiences that relay an understanding and ability to work with members of different racial and ethnic backgrounds; and 4) relevant or volunteer experience in education.

While there are no special admission standards for mathematics and science students, two universities (Arizona State University and the University of Arizona) requires students to submit materials that provide evidence of their work in education. For mathematics and science students, the supporting material could include experiences that are relevant to mathematics and science such as: observing in a mathematics or science classroom, working at a museum, working with scientists or mathematicians on curriculum, or tutoring mathematics or science students.

2.1 Traditional Initial Certification Programs in Science

Arizona Regents' Universities provide elementary and secondary students with a variety of options for their science specialization. In addition, post-baccalaureates who complete the planned course of study can attain state certification in their area of science. Depending upon the institution, post-baccalaureates can also obtain both a certificate and a Master's degree when they complete their initial certification program. The following discussion will specifically attend to traditional certification programs for baccalaureates.

Elementary education students, who are not specializing in science, are required to take eight (Arizona State University, Arizona State University West, NAU) to twelve (University of Arizona) hours of lab science and one science methods class. These requirements meet, but do not exceed, the requirements of the Arizona Department of Education. Elementary education students who elect to pursue an academic specialization

BEST COPY AVAILABLE

in science are required to take an additional two to four courses in science - for a total of eighteen hours. At Arizona State University, Arizona State University West, and the University of Arizona, elementary students who are seeking a science specialization are not required to take upper division science courses to complete their eighteen hour requirement. At the University of Arizona, elementary students are required to take a "Philosophy of Science" course as one of their science electives.

Secondary students in science education can major in several areas: biology, chemistry, ecology and evolutionary biology, geology, physics, and physical science. The programs offered at each of the Arizona Regents' Universities are located in Appendix C. Most of the science programs consist of a blend of pedagogical and content courses. In some cases, only one pedagogical course is required, while in other cases, up to four courses are required. Pedagogical courses in science education often emphasize learning theories, instruction, and curriculum; the areas stressed in the *National Science Education Standards* (National Research Council, 1996). It is doubtful that these areas are adequately covered in one or two courses, and it is unlikely that science courses attend to these topics. Most minors in science areas are not required to take corresponding pedagogical coursework, yet students who obtain a minor in a science area will more than likely be teaching in that area. Finally, each initial certification program, comprised of both pedagogy and content, did not exceed the 120 hour credit limit set by the Arizona Board of Regents.

The examination of initial certification programs in science also revealed a need for interdisciplinary approaches, the inclusion of the history or philosophy of science, and middle school programs. An interdisciplinary approach in science is advocated by both the *National Science Education Standards* (National Research Council, 1996) and the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993). Programs for elementary teachers who are acquiring a science specialization, and the program in Physical Science at Northern Arizona University demonstrate an integrated approach. In addition, initial certification programs that require a history of science or a philosophy of science course are congruent with the recommendations made by the national science reforms documents and science educators (American Association for the Advancement of Science, 1993; Duschl, 1994; Matthews, 1994). Unfortunately, the requirement of a history or philosophy course in science is inconsistent among Arizona Regents' Universities. The only programs requiring a course on the history and philosophy of science are the elementary science specialization at the University of Arizona and biology education degree at Arizona State University. Finally, tradition initial certification programs in science that are crafted to meet the needs of middle school educators are few. Only Northern Arizona University offers a science program that is geared towards instruction at the middle school level. Both national science reform documents discuss the need for science educators to be knowledgeable of appropriate middle level (5-8) science instruction.

2.2 Traditional Initial Certification Programs in Mathematics

Each Arizona Board of Regents' University provides coursework that enables elementary and secondary students to complete their mathematics specialization or certification. Depending upon the institution, post-baccalaureates can obtain both a certificate and Master's degree when they complete their initial certification program. It is important to state that this section examines just initial certification programs, specifically baccalaureate programs.

Elementary education students, who are not specializing in mathematics, are required to take four (University of Arizona) to six hours (Arizona State University, Arizona State University West) of mathematics and one mathematics methods class. While the number of required hours in mathematics is less than the number of hours recommended by the Mathematical Association of American (1991) and the National Council for Accreditation of Teacher Education (1989), the number of hours in mathematics does meet the Arizona State Department of Education requirement. Elementary education students who elect to pursue an academic specialization in mathematics are required to take an additional two to four courses - for a total of eighteen hours. Elementary students who are seeking a mathematics specialization are not required to take upper division mathematics courses in order to complete their eighteen hour requirement.

Secondary students in mathematics have one program of study. The programs offered at each of the Arizona Regents' Universities are located in Appendix C. Most of the mathematical programs consist of a blend of pedagogical and content courses. Two or three pedagogical courses are included within each mathematics program. The methods courses offered are specific to mathematics (as opposed to general methods courses), and they appear to be taught by both College of Education faculty and College of Arts and Sciences faculty. Mathematics education minors are not required to take pedagogical courses. This is an area of concern, given that mathematical minors will more than likely teach mathematics.

The mathematical education programs at each Arizona Regents' University are consistent and inconsistent in offering courses that supplement the traditional mathematical curriculum. All universities consistently require mathematics education majors to take a course in computer science and statistics. Arizona State University, Arizona State University West, and Northern Arizona University both require an applied statistics class, while the University of Arizona requires probability theory. All require that courses be completed in computer science. The *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991), and the *Curriculum and Evaluation Standards for the Teaching of School Mathematics* (National Council of Teachers of Mathematics, 1989) stress the importance of mathematics in a relevant setting. Computers and statistics are both relevant applications of mathematics, and thus the universities appear to be requiring appropriate coursework in these areas. There is inconsistency at each university in regards to the history and philosophy of mathematics,

and statistics. Only Northern Arizona University requires a history and philosophy of mathematics class.

2.3 Alternative Initial Certification Programs in Mathematics or Science

Mathematics and science students who are seeking an initial certification have the option to complete a post-baccalaureate certification program, or they can enroll in a MAT program that results in Master's degree and a certificate to teach. Each Arizona Regents' University offers a post-baccalaureate certificate, while only two universities offer a Master's degree that can be combined with a teaching certificate.

Post-baccalaureate programs for elementary and secondary students are quite different. While elementary students are required to take the required specific education courses, they are also required to take courses that enable them to instruct within several disciplines. Post-baccalaureate programs for elementary majors can be completed in as little as a year-and-a- half, with most student taking two to three years. Secondary post-baccalaureates are required to take specific education courses and any subject matter courses that are required in their teaching major. For example, a chemistry student who has completed all of the chemistry major courses will only have to take the required education courses. Post-baccalaureate programs for secondary students can be completed in as little as a year, with most students taking two to three years. The amount of time required to complete a post-baccalaureate degree often depends upon the students' current obligations to their jobs and families. Most post-baccalaureate programs require the student to finish in five to six years.

Students who are seeking certification and a Master's degree can do so at two institutions: Northern Arizona University and Arizona State University. In both cases, students are required to complete the post-baccalaureate requirements for initial certification and the Master's degree program in science or mathematics education. In essence, a student participates in both programs simultaneously. Students who enroll full-time can complete their Master's degree and certification requirements in three years.

An option to the traditional post-baccalaureate program can be found at Arizona State University. Teacher Education for Arizona Mathematics and Science (TEAMS) is an intensive, one year, post-baccalaureate program designed to prepare middle school science and mathematics teachers. This program was specifically designed to attract recent graduates and mid-to-late career individuals in science, mathematics, and technology. Students who complete the program attain an Middle Level Endorsement, a Secondary School Teacher Certificate, and a Master's degree in Curriculum and Instruction.

TEAMS is the only optional initial certification program that was developed specifically for middle school mathematics and science teachers. Other optional certification programs are developed to accommodate a variety of majors, with participants having the option to specialize in mathematics or science. These programs tend to take longer than a year.

There are clear benefits and detriments with each program, and these should be assessed by students prior to their enrollment in either.

2.4 Community-based University Partnership Programs

In addition to the traditional initial certification programs that are offered in Arizona, Arizona State University and the University of Arizona offer initial certification programs that are community-based. These programs are housed within a K-12 school district or a community, they are developed in response to a community or school district concern/need, and they encourage community and university partnerships. Participants who enroll in these programs earn either a Bachelor's degree or a Teaching Certificate in their area of specialization. These programs are:

- SCALES Elementary Program (ASU) - A quality "fast track" teacher certification program for post-baccalaureate students who want to work with students who are from culturally diverse backgrounds.
- Urban Teacher Corps Program (ASU) - A program to prepare culturally diverse and bilingual teachers for future employment in an urban educational setting.
- White Mountain Apache Teacher Preparation Partnership (ASU) - A program designed to prepare members of the White Mountain Apache Tribe for teaching positions in elementary education.
- Diné Teacher Education Program (ASU) - A program designed to prepare Navajo students for K-8 teaching positions through approaches that promote Navajo philosophy, culture, history, language and literacy.
- Flowing Wells Program (UA) - A one-year cohort program that is housed within the Flowing Wells district.
- Pima Community College Program (UA) - A program designed to assist and prepare minority students to enter education at the University of Arizona.

These programs, with the exception of the Flowing Wells program, address a specialized need in the Southwest; the need for teachers who are culturally diverse or who are trained to work with culturally diverse youth. Arizona State University has clearly sought to meet the needs of the communities that it serves and the needs of the Southwest. While none of the above mentioned programs are designed specifically for mathematics and science teachers, they do allow for a mathematics or science specialization.

2.5 Experiences that Earn Certification Credit

From the information received, there is one type of experience that will earn a student credit that can be applied towards his/her initial teaching certificate. Arizona State University West was the only university to described an instance in which they give credit for previous experiences. A collected document specifically stated:

Occasionally, students will offer strong backgrounds in working with public school students prior to their entry into one of our programs, for example working as a teacher's aide. Under these conditions, we may waive some or many of the field experience requirements that pertain to a program.

2.6 Advising of Initial Certification Students

Students are advised by different faculty and staff depending upon the initial certification that they are seeking. Faculty and staff who are responsible for advising are active in science and mathematics education programs, or they are hired to specifically advise students.

Elementary undergraduates at each university are advised through the College of Education. Arizona State University West, for example, has four full time advisors to assist elementary undergraduates. At each university, elementary undergraduates are advised early in their program about coursework and the process of applying to an elementary education program.

Secondary undergraduates at Arizona State University, Arizona State University West, and the University of Arizona are advised by staff from the College of Education and faculty from the College of Arts and Sciences. Advisors from the College of Education advise undergraduates about educational coursework, while mathematics and science specialists advise students about their content coursework. Northern Arizona University science and mathematics education students are advised primarily by biology, chemistry, earth science, physical science, or mathematics faculty.

At Arizona State University, Arizona State University West, and the University of Arizona, post-baccalaureates are advised through the College of Education. At Northern Arizona University, post-baccalaureates are advised through their respective departments.

Advising that consists of only one person is the least complex. Multiple advisors of programs require that both colleges (College of Education & College of Arts and Sciences) be informed about the practices of the other. In addition, separate advisors run the risk of providing students with inaccurate information about initial certification programs.

2.7 Supervision of Student Teachers in Initial Certification Programs

At each Arizona Regents' University the student teaching experience was noted as being a critical part of the initial certification program. Below are the descriptions provided by each Arizona Regents' University concerning the people who supervise the student teaching experience and the structure of that experience.

University	University Supervisors	Structure of Student Teaching Experience
Arizona State University	Student teachers are supervised by full-time faculty, full-time faculty associates, and part-time faculty associates. All supervisors must attend the Assessment and Supervision of Instruction orientation prior to being eligible as a supervisor. There are orientations every semester.	The field experience requires five or six visitations or more depending upon how well a student teacher is progressing. Approximately six visitations are planned and the students are also required to attend three evening seminars which are facilitated by the students' supervisor.
Arizona State University West	Student teacher supervisors are part-time staff members whose primary responsibilities are to supervise student teachers. These individuals are qualified retired teachers, retired principals, or doctoral students. Supervision assignments are made on the basis of expertise and geography. There are monthly professional development seminars for supervisors.	Supervisors are required to make five visits, including a minimum of three scheduled visits. There are also conferences with the student, the cooperating teacher, and administrators as needed. Additionally, supervisors hold two proseminars with their students, and a student teaching seminar is required of all students. Students are formally evaluated three times during their student teaching.
Northern Arizona University	Student teachers are supervised by on-campus NAU faculty. Outside of Flagstaff, student teachers are supervised by qualified individuals in the area. These people may be principals, superintendents, or retired faculty.	The students teachers are observed on five occasions, with each visit being a minimum of two class periods. There are also conferences with student teachers, cooperating teachers, and administrators as needed. Progress reports (2) and evaluations (2) are also prepared.
University of Arizona	Student teachers are supervised by College of Education faculty and graduate students, or qualified individuals hired by the College of Education. At the secondary level, all attempts are made to have students supervised by mathematical or science educators. All supervision is directed by the College of Education. All supervisors, who are not faculty, participate in a supervision workshop.	Student teachers are visited a minimum of eight times during their student teaching experience. Each visitation is accompanied by a conference. There are 3 Saturday professional development seminars for student teachers. A mid-term and final report documents the progress of each student teacher.

Most student teachers will see their supervisors at least five times in their classes and three to ten times outside of their classes (seminars, professional development meetings, etc.). From the information provided, it is clear that a variety of professionals are supervising the

BEST COPY AVAILABLE

field experience of mathematics and science students. The professionals supervising the field experience range from retired educators, to graduate students, to faculty members (who are primarily mathematics educators, science educators, or education specialists). It was also unclear to what degree subject specific majors (for example, biology or physics) were supervised by related specialists (professors in biology or physics).

Some institutions require their supervisors to attend training sessions (Arizona State University, Arizona State University West, and the University of Arizona), while others did not (Northern Arizona University). The focus of the training sessions, the duration of the training sessions, and the supervisors who where required to attend varied among universities. In addition, it was not clear if supervisors participated in on-going professional development after their initial training.

Field experiences and student teaching are frequently noted as being the most important part of an initial certification program. Student teachers are socialized into the culture of the school, and they begin to learn how to enact pedagogically sound instruction. Throughout this process of professional development, student teachers should be encouraged to build their understanding of their discipline, and they should learn how to reflect upon their practice (National Council of Teachers of Mathematics, 1991; National Research Council, 1996). Supervisors, in conjunction with the cooperating teacher, can assist student teachers in their professional development. In order to be an active participant in this process, it is important that the supervisor be knowledgeable of the area he/she is supervising and he/she should enact some form of supervision practice (e.g. clinical supervision, reflective practice, etc.) (Glickman & Bey, 1990). A continued effort should be made to provide adequate training for supervisors and to insure that appropriate supervision methods are utilized.

2.8 Programs / Projects that Support the Initial Certification of Teachers

At each Arizona Regents' University there are several programs or projects that support the initial certification of teachers in mathematics or science. These programs or projects provide seminars, contacts, support, service, and work opportunities to initial certification students. One of the most significant projects is:

- Project: Arizona Collaborative for Excellence in the Preparation of Teachers (ACEPT) (Arizona State University) - This project is funded by the National Science Foundation for five years to reform introductory general science and mathematics courses taken by K-12 pre-service teachers in several public institutions in the Southwest.

In examining the submitted materials, Project ACEPT has made substantial contributions towards the restructuring of several mathematics and sciences course that are taken by initial certification students. Ultimately, this program will reform how mathematics and science classes are taught at Arizona State University.

2.9 Concluding Remarks: Initial Certification Programs

The initial certification programs in mathematics and science at Arizona Regents' Universities are consistent yet varied. Admission procedures, initial certification programs in mathematics, and elementary specialization requirements are generally consistent among all four universities. Admission procedures usually require that undergraduates have completed 56 hours, hold a minimum GPA, and have successfully demonstrated basic skills. All initial certification programs in mathematics require content, application (statistics and computer science), and pedagogical courses. Only one university required a course on the history and philosophy of mathematics. Elementary majors who specialize in mathematics and science are required to complete eighteen hours in mathematics and science. In some cases, elementary teachers have the opportunity to experience both content knowledge and pedagogy within one course.

The variation of initial certification programs is prevalent within secondary science programs and the field experience. In science, only one program is integrated (composed of a variety of science courses), only a few programs are designed for middle school science teachers, some programs have ample pedagogy, some programs include history and philosophy of science, and some programs are intensive and field-based. Based upon the *National Science Education Standards* (National Research Council, 1996) and the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993), science education programs should include the history and the philosophy of science, present science as an integrated discipline, address middle level science education, and teach science through inquiry. These areas should be attended to by those who participate in and guide initial certification programs for mathematics and science students.

Another variation that exists within initial certification programs is the student's field experience. There is a large degree of variation between universities in the number of times a student teacher is visited by a university supervisor. It is also unclear to what degree subject specific majors (for example, biology or physics) are supervised by related specialists (professors in biology or physics). In addition, the focus of the training sessions for supervisors, the duration of the training sessions for supervisors, and the supervisors who where required to attend varied among universities. It was also not clear if supervisors participated in on-going professional development after their initial training.

Finally, our examination of initial certification programs in mathematics and science it revealed that students who may be teaching mathematics or science are not adequately trained. Secondary students who obtain a teaching minor in science or mathematics are not required to take courses in mathematics or science pedagogy. Elementary students who will be teaching science and mathematics often do not have adequate preparation in either mathematics or science, yet they will be asked to regularly teach both mathematics and science. Our findings here are similar to those stated in the *Indicators of Science & Mathematics Education* (National Science Foundation, 1992); specifically, the inadequate preparation of teachers who will be teaching in their minor and the inadequate preparation of elementary teachers.

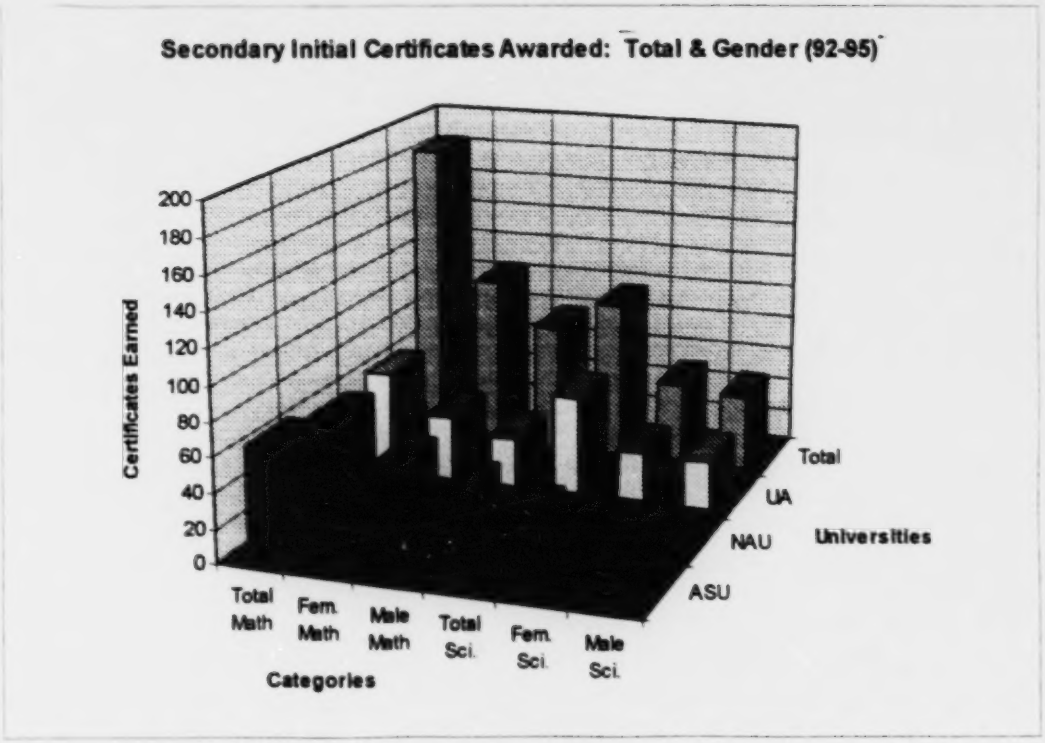
Who are the students in initial certification programs in mathematics and science at Arizona Regents' Universities?

The participants in initial certification programs in mathematics and science are both varied and diverse. They are undergraduates who are earning their first degree, and they are post-baccalaureates who are pursuing certification. Some students will attend school full-time for four years, while other students will attend part-time for up to six years. Some students will begin their program at the age of 17, while others will start at the age of 45. By examining the composition of the student body that is involved in initial certification programs, it is possible to determine who participates and completes these programs. This information is valuable in designing programs that will meet the needs of future and current participants.

3.0 Awarded Certificates & Gender of Initial Certification Students

Specific data were not reported by all of the universities in regards to the number of elementary education majors who earned initial certificates with mathematics or science specialization during the last three years. This is due in part to the difficulty in tracking the attainment of an elementary specialization in mathematics or science. Of the universities who did report on their elementary education students who were pursuing an initial certification degree, there were typically more females than males in elementary education, and more students specialized in science instead of mathematics. The high number of female students is consistent with national data which at times reports 90% of all elementary teachers to be female (National Science Foundation, 1992). The number of elementary students who specialize in science is inconsistent with national data. Nationally, elementary students tend to specialize in mathematics and not science (National Science Foundation, 1992).

During the last three years, 183 secondary students have received their initial certification in either science or mathematics. Reported data from three universities indicated that 67% of the initial certificates awarded were in mathematics, while 33% of the initial certificates awarded were in science. For the most part, females and males are equitable in their acquisition of initial certification awards in mathematics and science. Nationally, at the secondary level there are more teachers in mathematics than science, and there are more the men than women who are mathematics or science teachers (National Science Foundation, 1992).



3.1 Ethnicity of Initial Certification Students

Specific data were not available on the ethnicity of elementary students who had earned their initial certification in either mathematics or science. Of the one university that did supply ethnic data on elementary students, the reported numbers were congruent with the national average. Specifically, a majority of elementary teachers are White/Caucasian, while a small percentage comprised other ethnicities (National Science Foundation, 1992).

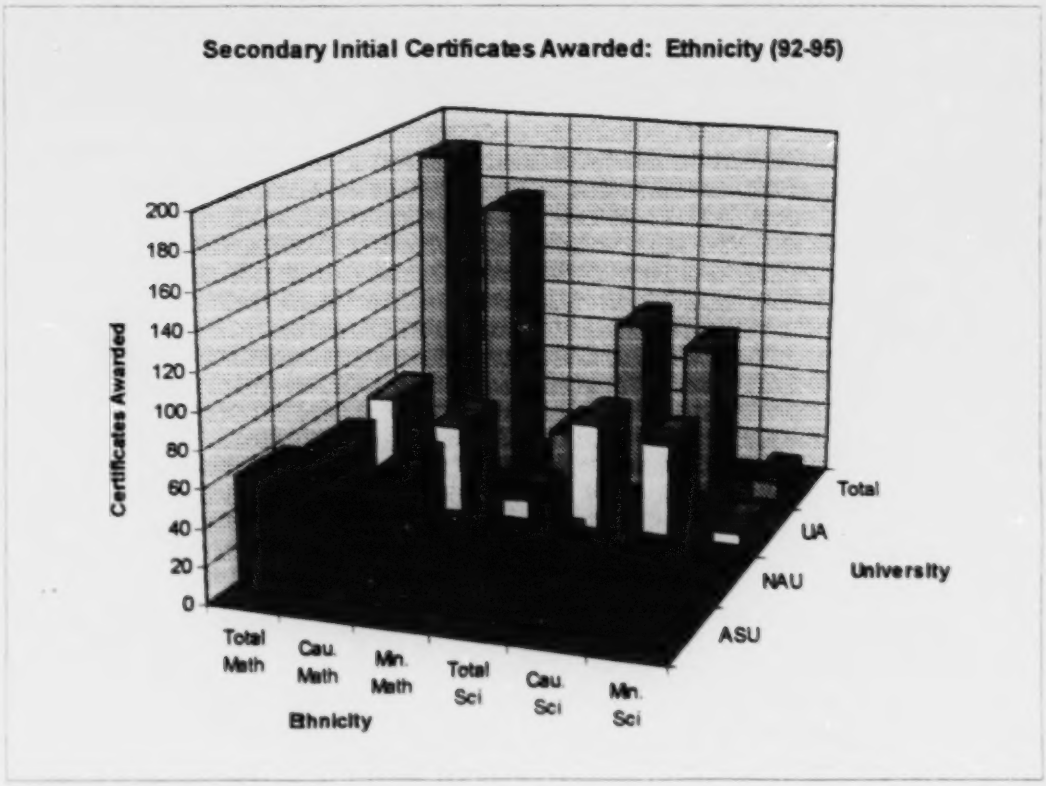
The large portion of White/Caucasian students, compared to other ethnicities, continues for secondary students who are awarded an initial certificate to teach in science or mathematics. Again, this trend is congruent with national data (National Science Foundation, 1992).

With the increasing diversity in Arizona schools, that lack of ethnically diverse teachers is a concern. This concern is best echoed by the Division of Research, Evaluation and Dissemination, Directorate for Education and Human Resources (National Science Foundation, 1992):

> Because a gap exists between the percentages of minority teachers and students, it is not surprising that most minority students do not have minority teachers. The paucity of minority teachers is doubly unfortunate: minority students and, in an increasingly heterogeneous society, all students need to see effective teachers who come from different background, ethnic groups, and races (p. 91)

BEST COPY AVAILABLE

Again, this is a significant area of concern for Arizona Regents' Universities given the diverse population of students that can be found in Arizona's public schools.



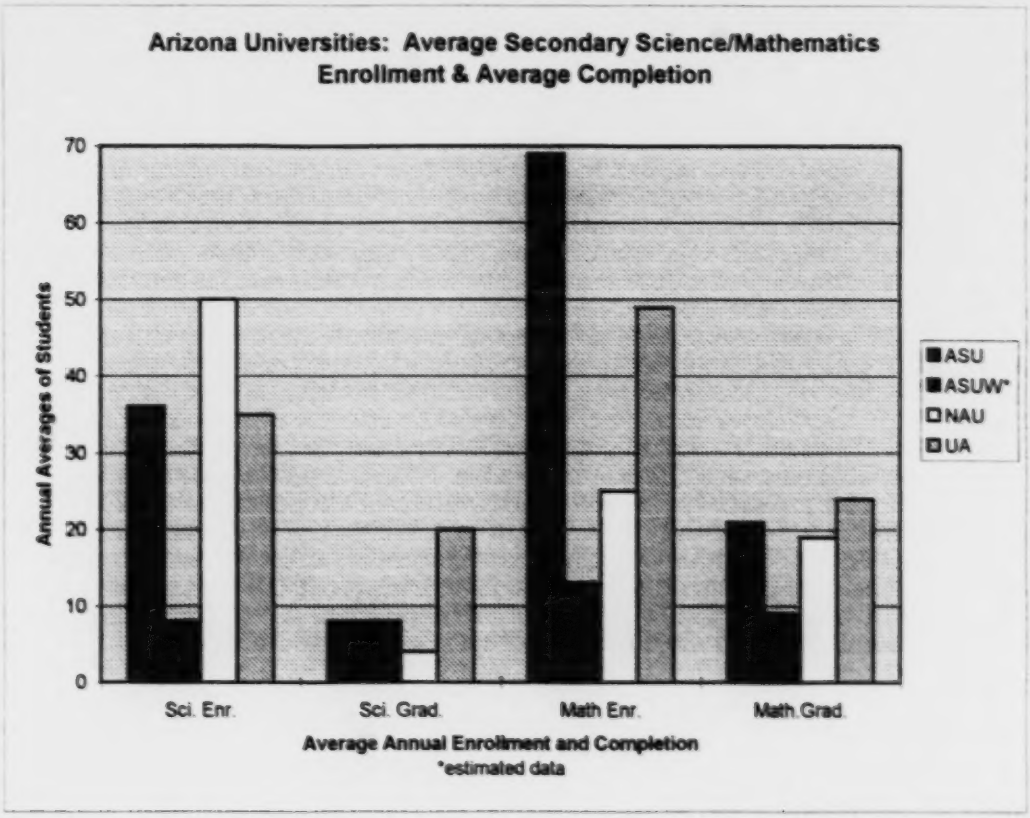
3.2 Enrollment and Certifications

This final section examines the students who are enrolled and the students who have been awarded their initial certification. Specifically, this last section takes the average enrollment of secondary mathematics and science students during a year, and compares it with the number of students who were awarded their initial certificates in a year. Three years of enrollment and completion data were collected and averaged to determine the annual numbers.

During a year, it would be expected that there would be a higher number of students enrolled than students graduating, as there are always students in the process of attaining their initial certification degree. For the most part, the University of Arizona (mathematics and science) and Northern Arizona University (mathematics) demonstrate consistency in enrolling and graduating their students. Arizona State University (mathematics and science) and Northern Arizona University (science) have a higher number of people in the process of attaining a degree than graduating. At Arizona State University the discrepancy may be due in part to the large number of programs that are offered off-campus. While it is encouraging to know that a substantial number of students are

BEST COPY AVAILABLE

enrolling in science and mathematics education programs, it is a concern that they are not graduating in a timely manner.



Based upon the reported data, between eighteen and twenty-four mathematics students a year complete their initial certification requirements at Arizona State University, Northern Arizona University, and the University of Arizona. In science, about twenty students a year complete their requirements for certification at the University of Arizona, while between eight and five students a year respectively complete their certification requirements at Arizona State University and Northern Arizona University.

3.4 Concluding Remarks: Initial Certification Students

At Arizona Regents' Universities there are more initial teaching certificates earned in mathematics than science, and this trend is congruent with the national average for degrees awarded in mathematics and science. Females continue to make gains in attaining initial certification, and they are closing the gap on their male counterparts. Caucasian/White mathematics and science initial preparation students continue to significantly out number their Hispanic-American and Native-American counterparts. This problem is not unique to Arizona; it is a national trend.

BEST COPY AVAILABLE

In an effort to combat the problem of low enrollment and degrees awarded to minorities for the purpose of teaching, several outreach programs have been developed at Arizona Regents' Universities. Arizona State University currently has several out-reach programs that assist and support minority students becoming teachers, and hopefully teachers of mathematics and science. University of Arizona offers a program, through the local community college, to assist and prepare minorities students to become teachers. Both universities also offer support services within the College of Education to assist minority students in their academic studies. Clearly, more of these programs need to be developed and supported.

Finally, after collecting the data for this section it became clear that better methods are needed to track students who apply, enroll, and complete initial certification programs in elementary and secondary education. Numbers of students were often inconsistent between sources within a university, and at times no records were even present. Accurate record keeping will allow those who guide and participate in initial certification programs to better understand the strengths and deficiencies of their programs.

Who are the faculty and staff involved in initial certification programs in mathematics and science at Arizona Regents' Universities?

At each Arizona Regents' University, educators guide students through a program of study that ultimately leads to initial certification in mathematics or science. This section specifically examines educators who are involved in mathematics and science initial certification programs: who they are, what expertise they have, and their professional activity. The term mathematics and science educator will be used throughout this section to refer to this group of individuals.

Each mathematics and science educator who is affiliated with one of the four Arizona Regents' Universities in this study was asked to complete a survey that addressed the above mentioned areas. Overall, the survey had a 65% response rate. The process that was used to identify mathematics and science educators is located in the methods section under sample population/participant selection.

4.0 Profiles of Mathematics and Science Educators

Through a survey, information was gathered concerning mathematics and science educators who are at Arizona Regents' Universities. Some of the questions included: the level of appointment, the college they are appointed to, the highest degree attained, years in their current position, and amount of time spent in teaching, research, and service. The survey that was sent to mathematics and science educators can be found in Appendix B. This section reports the findings of the first seven questions in the survey.

Mathematics and Science Educators at Arizona Regents' Universities	
Attribute	% (n=66)
Area of Expertise	
General Education	15
Mathematics	14
Science	35
Mathematics Education	22
Science Education	14
Appointment	
Professor (Assistant, Associate, Full)	73
Lecturer	9
Staff	12
Graduate Student	6
College of Appointment	
Education	39
Mathematics	18
Science	35
Joint	8

Mathematics and Science Educators in Arizona (con't)	
Attribute	% (n=66)
Highest Degree	
Ph.D.	70
Ed.D.	14
M.S.	9
M.A.	6
Other	1
Years in Current Position	
1-5	54
5-10	20
10-20	12
20-30	14
Population Educator Typically Works With	
Elementary Students	55
Elementary Science Specialists	10
Elementary Mathematics Specialists	2
Secondary Science	24
Secondary Mathematics	8
Other	1
Time Spent Teaching Classes for Certification (%)	
0-25	50
25-50	32
50-75	10
75-100	8
Time Spent Teaching Classes Not for Certification (%)	
0-25	58
25-50	12
50-75	7
75-100	3
Service (%)	
0-25	87
25-50	13
50-75	0
75-100	0
Research (%)	
0-25	50
25-50	47
50-75	3
75-100	0

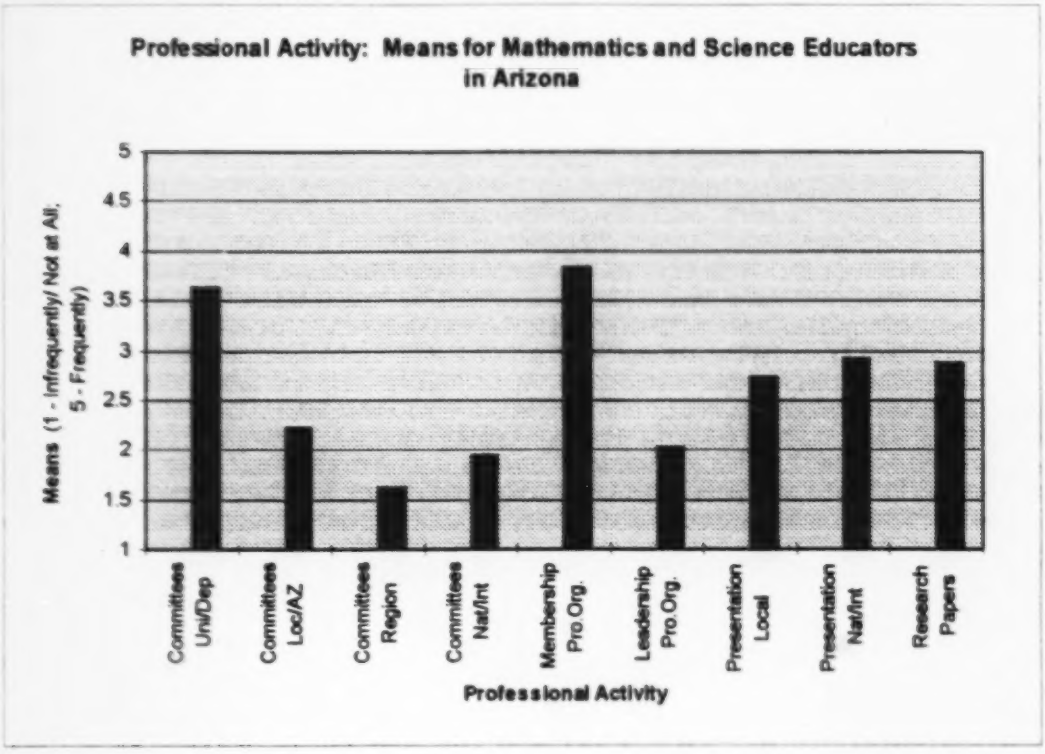
The survey revealed the attributes of those who are responsible for the mathematics and science education of initial certification students. Over half of the respondents indicated that their area of expertise was either mathematics education (22%) or science (35%). The other respondents were divided equally in their expertise between education, science education, and mathematics. A majority of the respondents (73%) indicated that they are professors, and over half (54%) responded that they have been at their institution for five years or less.

The respondents spend their time in a variety of ways. Most respondents teach both courses that are for certification and courses that are not for certification. In the areas of research and service, the trends are interesting. Participation in research tends to be a bi-modal distribution, with faculty and staff either conducting little to no research (0-5%) or a significant amount of research (40%). Most faculty and staff (75%) spend about 20% of their time participating in service activities.

4.1 Professional Activity of Mathematics and Science Educators

Professional activity is important. As educators are professionally active, they share ideas, build new understandings, and create more effective learning communities. The educators who work with initial certification students in mathematics and science were asked to report the types of professional activities in which they engaged in and the level of their activity.

In Arizona, mathematics and science educators are professionally active in a variety of areas. Most often they participate on departmental or university committees and they hold professional memberships. Some of the time, mathematics and science educators make presentations at local conferences and they present their research at national or international conferences. Occasionally, they participate on regional committees, national committees, and hold leadership positions in professional organizations.



BEST COPY AVAILABLE

To further examine the professional activity of mathematics and science educators, comparisons were made between the four Arizona Regents' Universities and between the departments in which the educators were appointed. There was no significant difference in the professional activity of mathematics and science educators between Arizona State University, Arizona State University West, Northern Arizona University, and University of Arizona.

At the departmental level (education, science, etc.) there were significant differences in three areas of professional activity. First, membership in professional organizations differed significantly between educators appointed in mathematics or science departments. Scientists tended to engage in professional memberships more often than mathematicians. This may be due to the high number of mathematicians who are appointed temporarily to fill certain roles in mathematics education. Second, presentations at local conferences differed significantly between education and mathematics faculty. Faculty in departments of education were significantly more active at local conferences than faculty from mathematics. Third, presentations of research at national or international conferences differed significantly between faculty in science, mathematics, education, and those faculty who held joint appointments. Specifically, science faculty tended to make more research presentations than faculty from the education and mathematics departments, and those faculty who held joint appointments tended to make more presentations than faculty from mathematics.

4.2 Concluding Remarks: Faculty and Staff

The collected survey data revealed four areas that are worthy of special consideration in regards to the faculty and staff who are involved in initial certification programs in mathematics and science at Arizona Regents' Universities. First, tenure-track faculty comprise the primary population that is working with initial certification students. A recent concern has been that undergraduate degree students are commonly being taught by teaching assistants. That does not seem to be the case in mathematics and science education in Arizona; most initial certification students are working with tenure-track faculty.

Second, the majority of people working with initial certification students are faculty who have less than six years of service. While it is important that faculty work directly with students, more experienced faculty in the fields of mathematics, science, and education are not typically working with initial certification students. The primary teaching force consists of assistant professors who are pursuing tenure.

Third, there are more scientists than science educators working with initial certification students. Scientists typically do not model exemplary instruction that is congruent with standards-based teaching. This is a concern in that science educators will teach how they are taught.

Fourth, in order to effectively guide initial certification students, science and mathematics educators must continue to be professionally active. This includes serving on local, state, and regional committees, attending conferences, participating in conferences, and sharing one's own research with colleagues. Currently, science and mathematics educators need to be more committed to their own professional activity.

What are the modes of curriculum, instruction, and assessment of faculty and staff who are involved in initial certification programs in mathematics and science?

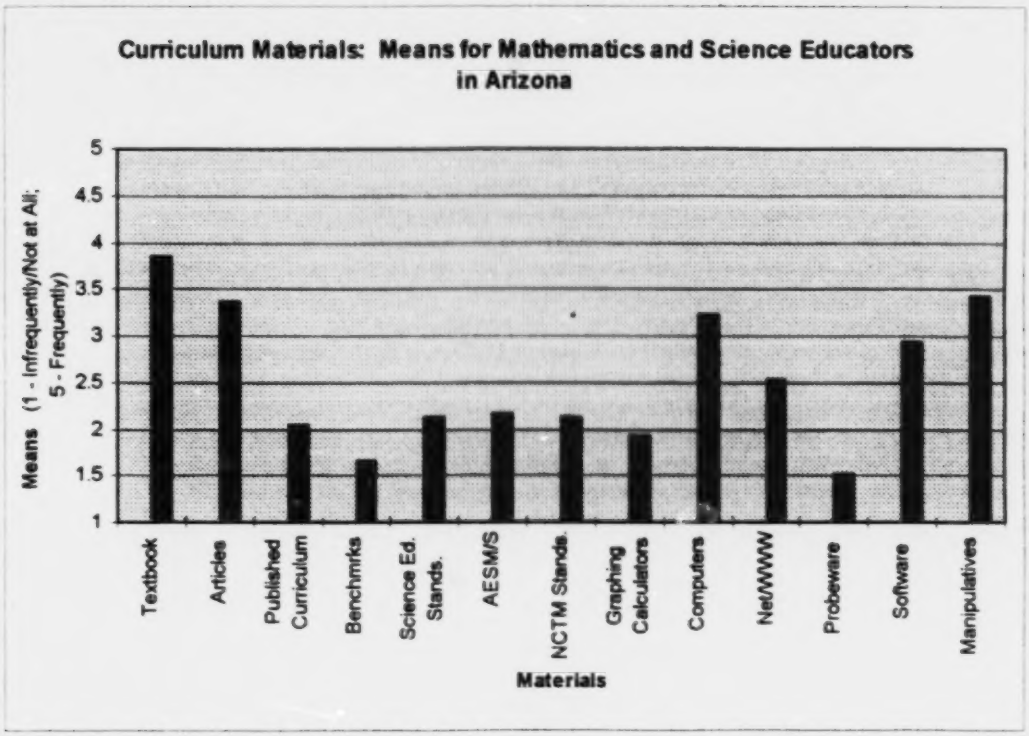
As well as knowing who is involved in the education of initial certification students in mathematics and science education, it is important to know the modes of curriculum, instruction, and assessment that are utilized by faculty and staff who work with initial certification students in mathematics and science. This section specifically examines the curriculum, the modes of instruction, and the forms of assessment utilized by mathematics and science educators at Arizona Regents' Universities.

5.0 Curriculum Materials of Mathematics and Science Educators

As mathematics and science educators conduct their classes, students should be introduced to a variety of instructional materials. This should include, but not be limited to: calculators, computers, calculator-based-laboratories, and various manipulatives. Students, depending upon their discipline, should also be familiar with the *National Science Standards* (National Research Council, 1996) or the *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991). These tools are utilized in today's societies and they are important tools in science and mathematics education.

In Arizona, mathematics and science educators are limited in their use of curriculum materials. Specifically, the textbook is the predominant curricular item utilized by mathematics and science educators. Articles, computers, and manipulatives are other commonly used curriculum items, but not to the degree of the textbook. Science and mathematics educators reported using the Internet, the World Wide Web, and computer software some of the time in their classes. They also reported using the *National Science Education Standards* (1996), the *Benchmarks for Science Literacy* (American for the Association for the Advancement of Science, 1993), and *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991) occasionally in their classes.

To further examine the use of curriculum materials, comparisons were made between universities and departments in which the educators were appointed. Among universities, there were significant differences in the inclusion of the standards and the use of probeware. Northern Arizona University faculty reported a significantly higher use of both the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) and the *Arizona Essential Skills* (Arizona Department of Education, 1990) than Arizona State University, Arizona State University West, and University of Arizona faculty. Northern Arizona University faculty also indicated that they utilized the *National Science Education Standards* (National Research Council, 1996) significantly more than Arizona State University West and University of Arizona faculty. In regards to probeware, Arizona State University faculty utilized probeware more than Arizona State University West faculty.



Among departments, there were significant differences in five areas. They are as follows:

- The use of a textbook. Faculty from mathematics departments utilize a textbook more than faculty from education departments.
- The use of published K-12 curriculum. Faculty from education departments utilize K-12 curriculum in their courses more frequently than faculty from science departments.
- The use of the Arizona Essential Skills. Faculty from education departments utilize the Arizona Essential Skills more than faculty from science, mathematics departments, and faculty who hold a joint appointment.
- The use of Internet and the World Wide Web. Faculty from education departments and faculty from science departments incorporate the Internet and the World Wide Web in to their courses more often than faculty from mathematics departments.
- The use of manipulatives. Faculty from education and mathematics departments utilize manipulatives more than faculty from science departments or faculty who hold joint appointments.

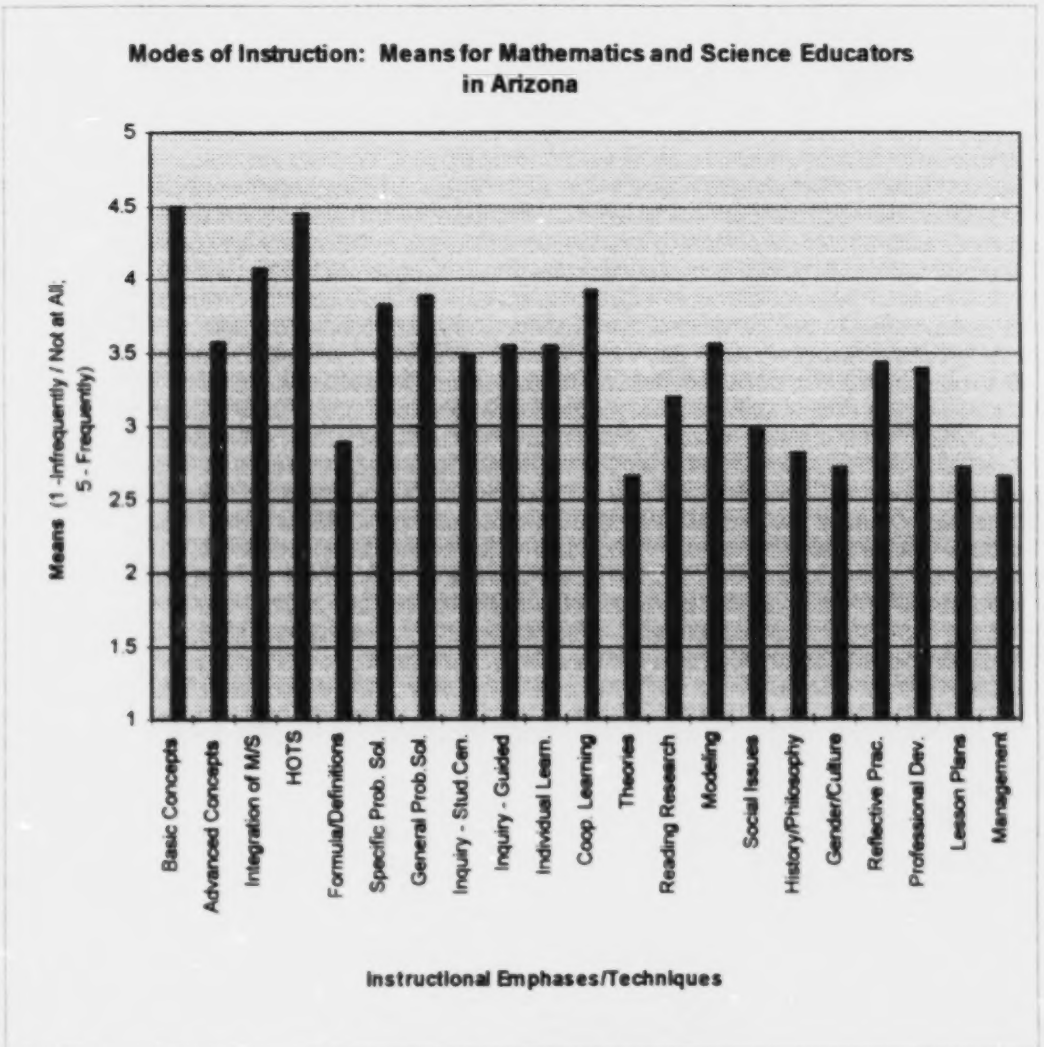
During the upcoming years, mathematics and science educators should increase their use of technology, the standards, and manipulatives. Future teachers should be familiar with technology, and they should know how to use it effectively in their classrooms. The use of technology (such as computers, calculators, and the Internet) is essential in today's changing society. Other Arizona Regents' Universities should also follow Northern

BEST COPY AVAILABLE

Arizona University's lead and incorporate the standards into more areas of instruction. The standards documents should be incorporated throughout an initial certification program in mathematics or science. For scientists, manipulatives can be any item that a student manipulates in order to solve a problem, answer a question, or conduct an investigation.

5.1 Instruction of Mathematics and Science Educators

Mathematics and science educators in Arizona utilize a variety of instruction techniques, and they have an different emphases during instruction (often depending upon the discipline). The items listed in the survey, to which Arizona mathematics and science educators responded, were based upon the *National Science Education Standards* (National Research Council, 1996), the *Professional Standards for the Teaching of Mathematics* (National Council of Teachers of Mathematics, 1991), and other state-wide surveys of mathematics and science educators.



BEST COPY AVAILABLE

During instruction, Arizona mathematics and science educators reported that they frequently emphasized the understanding of basic concepts and the use of higher order thinking skills to understand mathematical or science concepts. They reported that most of the time they integrated mathematics and science with other subjects. The emphases or instructional techniques that mathematics and science educators engaged in least (which equated to "some of the time") were theories that are involved in teaching mathematics, formulas and definitions that are found in mathematics and science, gender and culture, history and philosophy of science or mathematics, lesson plans, and classroom management.

To further examine modes of instruction that are utilized by mathematics and science educators, follow-up comparison tests were made between the four Arizona Regents' Universities and the departments in which the educators were appointed. Among the universities there were significant differences in the modeling of effective practice and the use of guided inquiry. In regards to the modeling of effective instruction, Arizona State University faculty spent more instructional time modeling effective mathematics or science instruction than University of Arizona faculty. The use of guided inquiry differed significantly between faculty at Arizona State University, Arizona State University West, and Northern Arizona University. Faculty at Arizona State University and Northern Arizona University reported utilizing guided inquiry (an inquiry in which faculty or assistants provide the questions and explorations) significantly more than faculty at Arizona State University West.

Among departments, there were significant differences in eight areas. They are as follows:

- The understanding of advanced science concepts/mathematical concepts. Faculty from both mathematics and science departments emphasized the understanding of advanced science and mathematical concepts more than faculty from education departments.
- The use of formulas and definitions for mathematics of science. Faculty from mathematics departments emphasized formulas and definitions more than faculty from education departments.
- The theories involved in the effective teaching of mathematics and science. Faculty from education departments emphasized learning and teaching theories more than faculty from mathematics and science departments.
- Modeling of effective mathematics and science instruction. Faculty from education departments spent more time modeling effective instruction than faculty from science departments and faculty who held joint appointments. Faculty from mathematics departments also spent more time modeling effective instruction than faculty from science departments.
- Becoming a reflective practitioner. Faculty from education departments emphasized self-analysis as a way to become a reflective practitioner more than faculty from science departments.

- The importance of on-going professional development. Faculty from education departments and faculty with joint appointments emphasized on-going professional development more than faculty from science departments.
- Creating daily, weekly, or yearly lesson plans. Faculty from education departments reported spending more time creating daily, weekly, and yearly lesson plans than faculty from science departments.
- Managing mathematics and science classrooms. Faculty from education departments reported spending significantly more time on classroom management than faculty from mathematics and science departments, and faculty holding joint appointments.

Faculty at Arizona Regents' Universities reported the use of a variety of instructional techniques and different emphases in their instruction. Furthermore, this section does supply evidence that faculty from different departments contribute differently to initial certification programs. Faculty from mathematics, science, education, and those who hold joint appointments, each bring an area of expertise that contributes to the entire initial certification program of each student. Students have effective practice modeled (although not often in their content courses), students have opportunities to learn basic concepts, and students have opportunities to learn about effective instruction (cooperative learning, planning, etc.).

5.2 Assessment Utilized by Mathematics and Science Educators

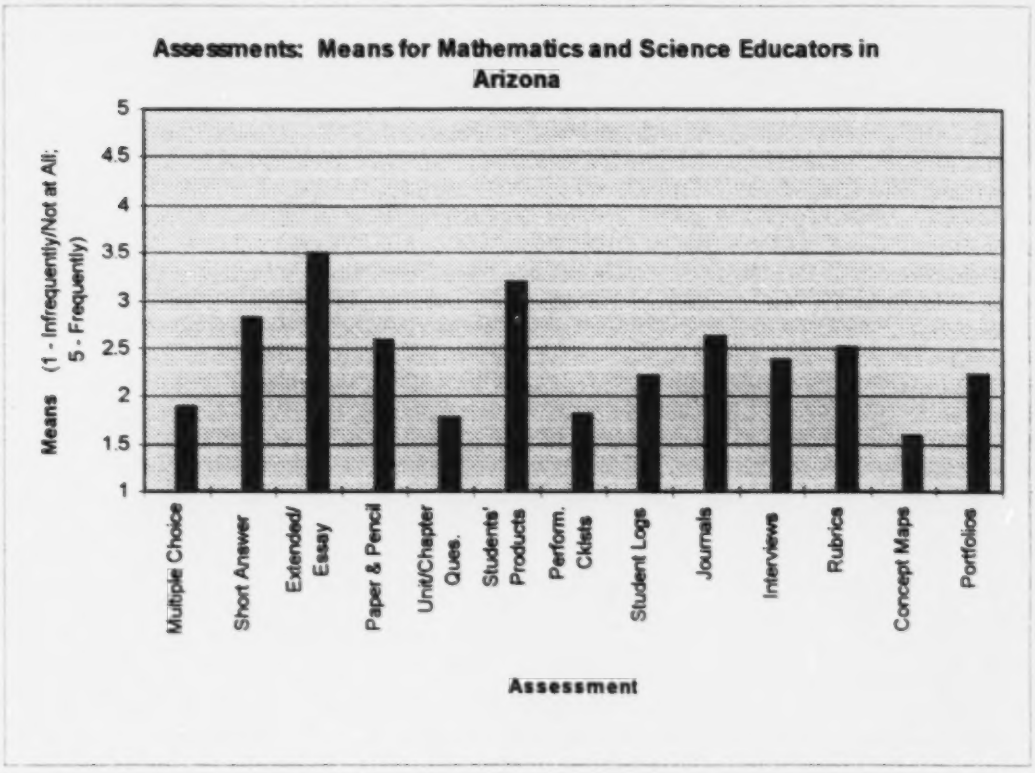
Assessment is an important part of instruction. Ideally, assessment should provide feedback to the student on how well he/she is understanding the course material; help the student to understand how they are learning; inform the teacher about the effectiveness of the curriculum; and it should provide the teacher with information about his/her instruction. This part of the survey was designed to understand how Arizona mathematics and science educators assess their students.

To assess students, extended answer, essay tests, and students' products are frequently utilized by mathematics and science educators in Arizona. Paper and pencil tests, short answer tests, journals, and rubrics are occasionally utilized when assessing students. Multiple choice tests, concept maps, end of the unit/chapter questions, and performance checklists are utilized least.

To further examine the use of assessment, follow-up comparisons were made between the four Arizona Regents' Universities and the departments in which the educators were appointed. There were no significant differences in the utilization of assessments between Arizona State University, Arizona State University West, Northern Arizona University, and the University of Arizona.

At the department level, there were significant differences in two areas of assessment. First, the use of students' products differed significantly between faculty from education departments and faculty from science departments. Education faculty utilized students'

products as a form of assessment significantly more than science faculty. Second, the use of performance checklists differed significantly between education faculty and science faculty. Faculty from education departments used performance checklists more than their science counterparts.



Assessment is an important area in mathematics and science education (National Council of Teachers of Mathematics, 1991; National Research Council, 1996). Currently, Arizona mathematics and science educators utilize a limited number of assessment techniques, and they frequently utilize techniques that are traditional (extended essay and products). Mathematics and science educators should integrate alternative assessments more frequently into their courses. These assessments could include, but would not be limited to: portfolios, concept maps, rubrics, and journals. Furthermore, alternative assessments are accepted and frequently utilized in science and mathematics settings (Muire, Abbas, Gilmer, & Davis, 1997), and they are congruent with the assessment practices espoused in the *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991)

5.3 Concluding Remarks: Curriculum, Instruction, and Assessment

The greatest challenge facing mathematics and science educators at Arizona Regents' Universities will be the reforming of curriculum, instruction, and assessment to be more

BEST COPY AVAILABLE

consistent with *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991). The current curriculum is limited, instructional practices vary between departments, and assessments are traditional. If mathematics and science educators continue on their current path, it is unlikely that students who are attaining their initial certification will be prepared to instruct today's students for tomorrow's world. But mathematics and science educators can not reform their curriculum, instruction, and assessment alone. Adequate funding, time, and support are needed to make the necessary changes.

During the next few years, adequate resources should be available for mathematics and science educators to specifically learn about technology in science and mathematics, effective mathematics and science instruction, and alternative assessments for mathematics, science, and education. These resources should include, but not be limited to: release time to reform courses, support for professional development to learn new methodologies, financial support for the acquisition of materials, and opportunities to visit with other colleagues who are attempting similar reforms. Failure to provide these resources will only perpetuate the current state of curriculum, instruction, and assessment.

Section IV: Recommendations

This study is an examination of initial certification programs in mathematics and science at Arizona Regents' Universities. It specifically sought to understand the guiding framework that influences initial certification programs, the initial certification programs at each university, the participants within initial certification programs in mathematics and science, and the faculty and staff who are responsible for the instruction in initial certification programs in mathematics and science. After examining each area, the following recommendations are made for initial certification programs at Arizona Regents' Universities:

- Implement systems to monitor initial certification students in mathematics and science. Throughout the data collection phase of this study, it was difficult to acquire complete and accurate data. Better systems need to be developed to monitor the students who are involved in initial certification programs in mathematics and science. This information is critical in understanding the effectiveness of our initial certification programs.

- Share and discuss mission statements. Mission statements are documents that guide colleges, departments, and districts. Our overview of mission statements found some consistency between and within university, college, and department mission statements. Mission statements should be shared within universities and between departments. Discussing mission statements will assist faculty and staff in understanding the mission of their university, college, and department.

- Recruit, enroll, and retain minority students in mathematics and science education. In Arizona, there is a need to recruit, enroll, and retain students who are interested in working with diverse cultures or who are from diverse cultures themselves. Our current initial certification program participants are not representative of Arizona's diverse population.

- Develop integrated science and mathematics classes/degrees for initial certification students. Both the *National Science Education Standards* (National Research Council, 1996) and the *Professional Standards for Teaching Science* (National Council of Teachers of Mathematics, 1991) stress the importance of relating disciplines to one another; including mathematics and science. Initial certification programs and courses should be available that show how disciplines in science are integrated and how mathematics and science are integrated. In the upcoming years this will be critical for new teachers as integrated courses become more predominate in our public schools.

BEST COPY AVAILABLE

- Develop initial certification programs in mathematics and science for middle level educators. The current dichotomy of elementary and secondary certification does not meet the needs of middle school science and mathematics. There is a need to create mathematics and science programs that specialize in initial certification for middle school instruction. Both Arizona State University and Northern Arizona University offer a middle level initial certificate specifically for mathematics and science education.

- Require pedagogical courses for mathematics and science minors. Initial certification programs at the secondary level require pedagogical courses in the students' major. Yet students with minors in science or mathematics are not required to take to pedagogical courses. This is problematic in that a number of students will be teaching in their minor without proper training.

- Encourage and reward faculty and staff for professional activities in mathematics and science education. Being professionally active includes serving on committees, participating in conferences, and sharing one's own research. Faculty and staff who are professionally active in mathematics education and science education are informed of the profession and they are able make important decisions about the future of mathematics and science education.

- Continue the support of faculty and staff in initial certification programs in mathematics and science to explore new curriculum, instruction, and assessment. Resources should be available for faculty and staff in initial certification programs in mathematics and science to explore new curriculum, methods of instruction, and alternative assessment. The resources need to be available for extended periods of time - as change is a process.

Bibliography

American Association for the Advancement of Science (AAAS) (1993). Benchmarks for science literacy: Project 2061. New York, NY: Oxford University Press.

Arizona Department of Education (1990). Arizona science essential skills. Phoenix, AZ: Research and Development Division.

Arizona Department of Education (1993). Arizona education profiles 1990-1991. Phoenix, AZ: Research and Development Division.

Baird, W.E., Prather, J.P., Finson, K.D., & Oliver, J.S. (1994). Comparison of perceptions among rural verses non-rural secondary science teachers: A multistate survey. Science Education, 78(6), 555-596.

Best, J.W. (1977). Research in education: Third edition. Englewood Cliffs, NJ: Prentice-Hall, Inc..

Bogdan, R.C., & Biklen, S.K. (1992). Qualitative research for education. Needham Heights, MA: Allyn and Bacon.

Duschl, R. (1994). Research on the history and philosophy of science. In Gabel, D. (Ed.) Handbook of research on science teaching and learning. New York, NY: Macmillan Press.

Finson, K.D., Fitch, T., Lisowski, M., & Foster, G. (1996). The status of science education in K-6 Illinois schools. School Science and Mathematics, 96(3), 120-127.

Fowler, F.J. (1993). Survey research methods: Second edition. Newbury Park, CA: Sage Publications.

Glasser, B., & Strauss, A.L. (1967). The discovery of grounded theory: Strategies for qualitative research. Chicago, IL: Aldine.

Glickman, C.D., & Bey, T.M. (1990). Supervision. In Houston, W.R. (Ed.) Handbook of research on teacher education. New York, NY: Macmillan Publishing Company.

Harrison, T. (1997). Final report of the NAU symposium on systemic reform in science and mathematics education. Phoenix, AZ: Arizona Science and Mathematics Program, Arizona Board of Regents.

Lazarowitz, R. & Tamir, P (1994). Research on using laboratory instruction in science. In D. Gabel (Ed.) Handbook of research on science teaching and learning. New York, NY: Macmillan Publishing Company.

Mathematical Association of America (1991). A call for change: Recommendations for the mathematical preparation of teachers of mathematics. Washington, DC: MAA.

Matthews, M.R. (1994). Science teaching: The role of history and philosophy of science. New York, NY: Routledge.

Muire, W.C., Abbas, A., Gilmer, P., & Davis, P. (1997, March). Non-traditional forms of assessment in university science and science education. Paper presented at the meeting of the National Association for Research in Science Teaching, Chicago, IL.

National Council for the Accreditation of Teacher Education (NCATE) (1989). Preparing and evaluation NCATE folios in science: The NSTA standards. Washington, D.C.: National Science Teachers Association.

National Council of Teachers of Mathematics (1989). Curriculum and evaluation standards for the teaching of school mathematics. Reston, VA: National Council of Teacher of Mathematics.

National Council of Teachers of Mathematics (1991). Professional standards for the teaching of mathematics. Reston, VA: National Council of Teacher of Mathematics.

National Research Council (1996). National science education standards. Washington, D.C.: National Academy Press.

National Science Foundation: Division of Research, Evaluation and Dissemination, Directorate for Education and Human Resources (1993). Indicators of science and mathematics education 1992, ed. Larry Suter. Washington, DC: National Science Foundation.

Rutherford, F.J., & Ahlgren, A. (1990). Science for all Americans. New York, NY: Oxford University Press.

Songer, C.J., & Mintzes, J.J. (1994). Understanding cellular respiration: An analysis of conceptual change in college biology. Journal of Research in Science Teaching, 31(6), 621-638.

Sowell, E.J., Buss, R.R., Fedock, P.M., Johnson, G., Pryor, B.W., Wetzel, K., & Zambo, R. (1995). K-12 Mathematics and science education in Arizona: A status report. Phoenix, AZ: Eisenhower Mathematics and Science Program, Arizona Board of Regents.

Sundberg, M.D., & Armstrong J. E. (1993). The status of laboratory instruction for introductory biology in US. The American Biology Teacher, 55 (3), 144-146.

Tobias, S. (1992). Revitalizing undergraduate science: Why some things work and most don't. Tucson, AZ: Research Corporation.

Appendix A

List of information deemed important to assessing the status of mathematics and science education programs at Arizona Regent's Universities

A Status Report of Initial Certification in Science and Mathematics at the Arizona Regent's Universities

Please collect the following information in regards to the last three years at your university:

I. Rationale

1. Goals/mission statements from College of Education/ College of Sciences

2. Goals/mission statements from several districts

II. Preservice Mathematics and Science Students (Elementary and Secondary)

3. Number of students enrolled in math and science education; indicate gender, age, and ethnicity

4. Number of students applied, admitted, and enrolled in mathematics and science education specialization at the elementary level; indicate gender, age, and ethnicity

5. Number of undergraduates earning a degree in mathematics or science education, and elementary majors with a mathematics or science specialization

6. Number of certificates that are earned pertaining to mathematics or science education, elementary and secondary

7. Number of MATs that have earned degrees

8. Typical background of students seeking certification or MATs

9. Area of specialization of the secondary science degrees (MATs, first degrees, and certification)

10. Number of years to obtain the first degree, the certification, or the MAT

11. Criteria for admittance to the degree granting or certification program

III. Programs in Elementary and Secondary Mathematics and Science Education

12. Courses required and programs (include hours) for first degree programs in mathematics and science education (elementary and secondary)

13. MAT and certification programs (include course sequences and hours required) that are available

14. Current and projected alternative programs for first degree students

15. Activities that can earn certification, graduation, or MAT credit

16. Programs that involve the schools, parents, or communities in the initial certification of students

17. Number of advisees and advisors in secondary and elementary mathematics and science education programs

18. People who advise

19. Models of assessment of initial certification programs; how is the assessment conducted and who is doing it

20. Number of student teachers per person

21. Types of people who supervise student teachers

22. Number of required visitations to student teachers

23. The assignment of supervisors to student teachers (how are assignments made)

24. Professional development of supervisors, is there any?

25. Program options that expand the initial certification experience

26. How do programs communicate with the community?

27. How do programs work within the community?

28. Special/externally funded projects that address the initial certification of teachers

Appendix B

Survey to faculty and staff involved in the initial certification of mathematics and science education students

A Status Report of Initial Certification in Science and Mathematics at Arizona Regents' Universities

The following survey is part of a larger study that examines the status of initial teacher certification programs in science and mathematics education at Arizona Regents' Universities. This study is funded by the Arizona Board of Regents with the specific purpose of describing the state of initial teacher certification at Arizona Regents' Universities. Your completion of this survey is **critical** in establishing a complete and accurate profile of science and mathematics educators in Arizona public universities. Please return this completed form in the postage paid envelope by December 15, 1996. All responses are confidential. The entire questionnaire will take approximately 30 minutes. If you have any questions about this study, please contact the person at your institution:

- Dr. Ray Buss, Arizona State University West, 602-543-6343
- Dr. Diane Ebert-May, Northern Arizona University, 520-523-9125
- Ms. Chula Eslamieh, Arizona State University, 602-965-7820
- Dr. Julie Luft, University of Arizona, 520-621-6436

Note:
Initial certification program- The program of study that is designed specifically for either undergraduates, graduates, or post-baccalaureates so that they may teach in elementary or secondary, mathematics or science classrooms. These courses include: required general studies mathematics and science courses, content courses that are specifically designed for future teachers, methods courses, general education courses, or field experiences.

Background Information

1. Area of expertise
   General Education ___ Mathematics _____ Science _____
   Mathematics Education ____ Science Education _____
2. Appointment (e.g. Associate Professor, Graduate Student) _____
3. College or department in which you are appointed (if a joint appointment indicate %):
   Education ____ Mathematics ____ Science ____ Department _____
4. Highest Degree Held: Ph.D. ___ Ed.D. ___ M.S. ___ M.A. ___ Other ___
5. Years in your current position: _____
6. Student majors you have typically worked with during the last **three** years:
   Elementary ____ Elementary Mathematics Specialization ____
   Elementary Science Specialization ____ Secondary _____
   Secondary Mathematics ____ Secondary General Science ____
   Secondary Science Specialization ____ Other _____

7. Time spent (in %) in academic responsibilities throughout the year (e.g. 50%, 10%, 20%, 20%):
   Teaching of courses for certification (including supervision of student teachers) ___
   Teaching of courses (math, science or education) **not** for certification: ____
   Research / Research students: ____
   Service: ____
   Other: ____ Please explain _____

General information about your professional activity

During the last **three** years, I have engaged in the following activities (1-6) in these areas (A-C):

1) Frequently 2) Most of the time 3) Some of the time 4) Occasionally
5) Infrequently / Not at all 6) Not applicable

A) Science/mathematics B) Mathematics education/science education C) Education

	1	2	3	4	5	6	A,B,C
1. Participation on department or university committee(s)	__	__	__	__	__	__	____
2. Participation on local or state committee(s)	__	__	__	__	__	__	____
3. Participation on regional committee(s)	__	__	__	__	__	__	____
4. Participation on national or international committee(s)	__	__	__	__	__	__	____
5. Membership in professional organization(s)	__	__	__	__	__	__	____
6. Leadership position in professional organization(s)	__	__	__	__	__	__	____
7. Presentation at local conference(s)	__	__	__	__	__	__	____
8. General presentation at national or international conference(s)	__	__	__	__	__	__	____
9. Research paper presentation at national or international conference(s)	__	__	__	__	__	__	____
10. Supervision of secondary student teachers	__	__	__	__	__	__	____
11. Supervision of elementary student teachers	__	__	__	__	__	__	____

Specific information about the content and/or pedagogical courses that you teach

Assessment - I use the following assessments (1-6) in my (A-C) courses:

1) Frequently 2) Most of the time 3) Some of the time 4) Occasionally
5) Infrequently / Not at all 6) Not applicable

A) Content courses B) Pedagogical courses C) Pedagogical and content courses

	1	2	3	4	5	6	A,B,C
1. Multiple choice tests	—	—	—	—	—	—	____
2. Short answer tests	—	—	—	—	—	—	____
3. Extended answer or essay questions	—	—	—	—	—	—	____
4. Paper and pencil tests and quizzes	—	—	—	—	—	—	____
5. Questions at the end of the chapter or unit	—	—	—	—	—	—	____
6. Students' science or mathematics products	—	—	—	—	—	—	____
7. Performance checklists	—	—	—	—	—	—	____
8. Student logs	—	—	—	—	—	—	____
9. Journals	—	—	—	—	—	—	____
10. Interviews with students	—	—	—	—	—	—	____
11. Rubrics	—	—	—	—	—	—	____
12. Concept maps	—	—	—	—	—	—	____
13. Portfolios	—	—	—	—	—	—	____
14. Other _____	—	—	—	—	—	—	____

Curriculum - *Instruction* - I emphasize the following (1-6) in my (A-C) courses:

1) Frequently 2) Most of the time 3) Some of the time 4) Occasionally
5) Infrequently / Not at all 6) Not applicable

A) Content courses B) Pedagogical courses C) Pedagogical and content courses

	1	2	3	4	5	6	A,B,C
15. The understanding of basic science / mathematical concepts	—	—	—	—	—	—	____
16. The understanding of advanced science / mathematical concepts	—	—	—	—	—	—	____

1) Frequently 2) Most of the time 3) Some of the time 4) Occasionally
5) Infrequently / Not at all 6) Not applicable

A) Content courses B) Pedagogical courses C) Pedagogical and content courses

	1	2	3	4	5	6	A,B,C
17. The integration of mathematics or science with other subjects	—	—	—	—	—	—	____
18. Using higher order thinking skills to understand mathematical or science concepts	—	—	—	—	—	—	____
19. The use of mathematical or science formulas / definitions	—	—	—	—	—	—	____
20. Using subject specific problem-solving strategies	—	—	—	—	—	—	____
21. Using general problem-solving strategies	—	—	—	—	—	—	____
22. Student-centered inquiry in which students ask their own questions, design their own explorations, and analyze their findings	—	—	—	—	—	—	____
23. Guided inquiry in which faculty or assistants provide the questions and exploration	—	—	—	—	—	—	____
24. Individual learning opportunities	—	—	—	—	—	—	____
25. Cooperative group learning opportunities	—	—	—	—	—	—	____
26. The theories involved in teaching mathematics or science effectively (e.g. constructivism, behaviorism, generative learning, etc.)	—	—	—	—	—	—	____
27. The reading and analyzing of research from education, science, or mathematics	—	—	—	—	—	—	____
28. Modeling of effective mathematics or science instruction	—	—	—	—	—	—	____
29. The use of a social issue as a way to understand mathematical or science concepts	—	—	—	—	—	—	____
30. The history and philosophy of mathematics or science	—	—	—	—	—	—	____
31. Gender or cultural issues in the learning of mathematics or science	—	—	—	—	—	—	____

1) Frequently 2) Most of the time 3) Some of the time 4) Occasionally
5) Infrequently / Not at all 6) Not applicable

A) Content courses B) Pedagogical courses C) Pedagogical and content courses

	1	2	3	4	5	6	A,B,C
32. Becoming a reflective practitioner through self-analysis	__	__	__	__	__	__	____
33. The importance of on-going professional development	__	__	__	__	__	__	____
34. Creating daily, weekly, or yearly lesson plans	__	__	__	__	__	__	____
35. Managing mathematics or science classrooms	__	__	__	__	__	__	____

Curriculum - *Materials* - I use the following materials (1-6) in my (A-C) courses:

1) Frequently 2) Most of the time 3) Some of the time 4) Occasionally
5) Infrequently / Not at all 6) Not applicable

A) Content courses B) Pedagogical courses C) Pedagogical and content courses

	1	2	3	4	5	6	A,B,C
36. A textbook	__	__	__	__	__	__	____
37. A collection of articles	__	__	__	__	__	__	____
38. Published K-12 curriculum	__	__	__	__	__	__	____
39. The Benchmarks for Science Literacy	__	__	__	__	__	__	____
40. The National Science Education Standards	__	__	__	__	__	__	____
41. Arizona Essential Skills in Science or Mathematics	__	__	__	__	__	__	____
42. The National Council of Teachers of Mathematics Standards	__	__	__	__	__	__	____
43. Graphing Calculators	__	__	__	__	__	__	____
44. Personal computers	__	__	__	__	__	__	____
45. The Internet or the World Wide Web	__	__	__	__	__	__	____
46. Probeware	__	__	__	__	__	__	____
47. Software	__	__	__	__	__	__	____
48. Manipulatives	__	__	__	__	__	__	____

Appendix C

Secondary Science and Mathematics Programs

Biology		
University	Content Courses	Pedagogical Courses
Arizona State University	• General Biology I & II; • Ecology; • General genetics; • Organic evolution; • Survey of the Plant Kingdom, or Flora of Arizona, or Comparative Invertebrate Zoology, or Vertebrate Zoology; • Plant Physiology; • General Bacteriology; • Microbiology Lab; • Basic Physiology; • Addition 6 hours in zoology and botany; • General Chemistry I & II; • Introduction to Geology, or Geology of Arizona; • Physics; • History of Biology or History and Philosophy of Science; • Pre-calculus	• Methods of Teaching Biology
Arizona State University West	• General Biology I & II • Biological Thought; • Fundamentals of Ecology; • General Genetics; • Organic Evolution; • Survey of the Plant Kingdom, or Flora of AZ; • Invertebrate Zoology, or Vertebrate Zoology; • Basic Physiology, or Hormones and Behavior; • Cell Biology, or Principles Biochemistry; • The Biology of Human Experience, or the Human Environment; • Marine Ecology, or Landscape Ecology or Genes, Race, and Society, or Global Environment; • General Chemistry I & II; • Introduction to Physics, or General Physics; • Pre-calculus	• Methods of Teaching Biology

BEST COPY AVAILABLE

Biology (con't)		
University	Content Courses	Pedagogical Courses
Northern Arizona University	• Plant Biology Lab; • Animal Biology Lab; • Biology of Microorganisms; • Ecology; • Genetics and Evolution; • Cellular and Molecular Biology; • Animal Physiology, or Plant Physiology; • 2 addition Lab courses, 6 hours of botany, 6 hours of zoology, and 40 hours of elective biology; • General Chemistry with Lab I & II; • Organic Chemistry; • Physics; • Algebra with trigonometry; • Statistics	• Issues in Science, Technology, and Society; • Secondary Science Teaching Practicum; • Seminary Secondary Science Education; • Laboratory Techniques for Teaching Science; • Resource Development for Teaching Science

BEST COPY AVAILABLE

Chemistry		
University	Content Courses	Pedagogical Courses
Arizona State University	• General Chemistry I & II; • Analytical Chemistry with Lab; • Organic Chemistry with Lab I & II; • Biochemistry; • Elementary Physicals Chemistry; • General Physical Chemistry; • Inorganic Chemistry; • Physics I & II; • Calculus I & II	• Methods of Teaching Chemistry
Northern Arizona University	• General Chemistry with Lab I & II; • Organic Chemistry with Lab I & II; • Analytical Chemistry; • Physical Chemistry I; • Inorganic Chemistry I; • Biochemistry; • Plant Biology, or Animal Biology; • Physics I & II; • Geology I & II; • Calculus I & II	• Seminar Secondary Science Education; • Laboratory Techniques for Teaching Science; • Resources Development for Teaching Science; • Integrating Science across the Middle School Curriculum
University of Arizona	• General Chemistry and Lab I & II; • Organic Chemistry with Lab I & II; • Analytical Chemistry with Lab; • Chemical Safety; • Physical Chemistry I & II; • Calculus I & II; • Physics I & II with Lab; • Biology I & II, or Geology I & II	• Chemistry demonstrations; • Special Methods: Science*; • Teaching of Biology Labs* or Physics Demonstrations*

* not required for chemistry teaching minors

BEST COPY AVAILABLE

Ecology and Evolutionary Biology		
University	Content Courses	Pedagogical Courses
University of Arizona	• Introductory Biology with Lab I & II; • Genetics or Plant Genetics; • 17 additional hours of upper-division course electives in 1) biological perspectives, 2) cell/molecular; 3) organismic; and 4) ecology/evolution; • General Chemistry I & II; • Physics I & II; • Calculus; • Statistics	• Biological materials; • Teaching Biology Lab*; • General Science Methods*

* not required for the minor

Geology		
University	Content Courses	Pedagogical Courses
University of Arizona	• Introduction to Physical Geology, or Introduction to Environmental Geology, or Introduction to Oceanography; • Historical Geology and Lab; • Introduction to Physical Geology Lab; • Calculus; • Calculus with Applications; • 12 elective units	• General Science Methods

BEST COPY AVAILABLE

Physics		
University	Content Courses	Pedagogical Courses
Arizona State University	• Physics I & II; • Methods of Math Physics; • Physics II; • Classic Particles, Fields, & Matter I & II; • Electrical Circuits & Measures or Physics Lab III; • Quantum Physics I or Modern Physics; • Philosophy of Science; • Calculus I, II, III; • Linear Algebra; • Differential Equations	• Methods of Teaching Physics, or Internship: Teaching Physics
University of Arizona	• Mechanics; • Thermodynamics and Relativity; • Electricity and Magnetism; • Optics and Quantum Theory; • Methods of Experimental Physics I & II	• Physics Demonstrations; • General Science Methods

BEST COPY AVAILABLE

Physical Science		
University	Content Courses	Pedagogical Courses
Northern Arizona University	• Introduction to Astronomy [m]; • Introduction to Physics; • Electronics for Science Students [s]; • Twentieth Century Revolutions in Physics; • Fundamental Chemistry [m]; • Chemistry I with Lab; • Chemistry II with Lab [m]; • Fundamental Organic Chemistry; • Fundamental Organic Chemistry Lab [m]; • Analytical Chemistry or Fundamental Biology [s]; • Weather and Climate I [s]; • Physical Geology and Lab [s]; • Plant Biology; • Animal Biology; • Pre-calculus [m]; • Calculus: Discrete Mathematics or Foundations of Mathematics [m]; • Modern Geometry [m]; • Applied Statistics [m]	• Seminary Secondary Science Education; • Laboratory Techniques for Teaching Science; • Resources Development for Teaching Science; • Integrating Science Across the Middle School Curriculum; • Methods of Teaching Mathematics

s = secondary only m = middle school only

BEST COPY AVAILABLE

Mathematics		
University	Content Courses	Pedagogical Courses
Arizona State University	• Intro. to Computer Science, or Applied Problem Solving; • Principles of Computing; • Calculus I, II, III; • Linear Algebra; • Mathematical Structures; • Introduction to Geometry; • Intermediate Calculus, or Advanced Calculus; • Abstract Algebra, or Theory of Numbers; • Applied Statistics	• Mathematics in the Secondary Schools; • Methods of Teaching Mathematics
Arizona State University West	• Intro. to Computer Science, or Applied Problem Solving; • Calculus I, II, III; • Linear Algebra; • Mathematical Structures; • Introduction to Geometry; • Advanced Calculus; • Abstract Algebra; • Introductory to Applied Statistics	• Mathematics in the Secondary Schools; • Methods of Teaching Mathematics in Secondary Schools
Northern Arizona University	• Calculus I & II; • Discrete Mathematics; • Elementary Number Theory; • Foundations of Mathematics; • Modern Geometry; • Introduction to Abstract Algebra; • History & Philosophy of Mathematics; • Applied Statistics	• Computer Applications for Mathematics Teachers; • Problem Solving in School Mathematics; • Methods of Teaching Mathematics
University of Arizona	• Computer Science Principles; • Calculus I & II; • Introduction to Linear Algebra; • Vector Calculus; • Mathematical Analysis; • Differential Equations; • Number Theory or Abstract Algebra; • Probability Theory or Theory of Probability; • Topics in Geometry or Geometry	• Workshop: Mathematics Education; • Mathematics in the Secondary School; • Special Methods: Mathematics

BEST COPY AVAILABLE